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REPUBLIC OF KENYA
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Capacity Needs Assessment for the Power System Readiness for Variable Renewable Energies (VRE) Project

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GLOSSARY

The following terms are frequently used in this publication. Within this context, the terms are used as described below:

Variable Renewable Energy	Renewable energy generators powered by wind, solar or tidal wave.
Variability	Sudden and often unexpected changes in power plant output due to the variation in energy input.
Uncertainty	Inability to consistently and accurately forecast the power output from variable renewable energy (VRE) sources.
Location constrained	VRE characteristic that limits its application to areas that have wind, solar, and tidal wave resources. VRE, unlike fossil fuel-based generators, requires siting to be in the same location as the fuel/energy source.
Flexibility	Ability of a power system to effectively balance variations in power generation and demand.
Baseload	The minimum level of demand on an electrical grid over a span of time, for example, one day or one week.
Peak demand	The maximum level of demand on an electrical grid over a span of time, for example, one day or one week.
Reserves	Extra generating capacity that is readily available and dispatchable by increasing the power output of generators that are already connected to the power system.
Ancillary services	Services supporting the proper operations of an electricity power system including frequency regulation, reactive power regulations, active power reservation and others.
Merit order	Method of ranking available electricity generation resources (used by power system operators) based on price, with the least cost appearing first in an ascending order, together with the amount of energy that will be generated.
SimSEE	Electric Energy Systems Simulation.
Firm Capacity	This is the amount of energy available for production or transmission, which can be guaranteed to be available at a given time. Firm energy refers to the actual energy guaranteed to be available and is not dependent on external factors such as weather conditions.

ACRONYMS

AGC	Automatic Generation Control
CaDRE	Capacity Needs Diagnostics for Renewable Energies
CNA	Capacity Needs Assessment
EPC	Engineering Procurement and Construction
EPRA	Energy and Petroleum Regulatory Authority
FiT Tariff	Feed-in Tariff
GDC	Geothermal Development Company
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GT	Gas Turbine
HCD	Human Capacity Development
IPP	Independent Power Producers
IRENA	International Renewable Energy Agency
KenGen	Kenya Electricity Generating Company Limited
KETRACO	Kenya Electricity Transmission Company Limited
LCPDP	Least Cost Power Development Plan
LTWP	Lake Turkana Wind Project
MOE	Ministry of Energy
MTP	Medium Term Plan
NuPEA	Nuclear Power and Energy Agency
PPA	Power Purchase Agreement
REREC	Rural Electrification and Renewable Energy Corporation
Solar PV	Solar Photovoltaics
TOR	Terms of Reference
VRE	Variable Renewable Energy

EXECUTIVE SUMMARY

As a component of the larger technical assistance project "Power system readiness for the integration of variable renewable energies (VRE)" being implemented by the Ministry of Energy and GIZ, this assignment entailed conducting a Capacity Needs Assessment (CNA) of stakeholders involved in VRE deployment in the energy sector and subsequently designing a Human Capacity Development strategy to bridge identified capacity gaps. This was done primarily using the approaches prescribed by the Capacity Needs Diagnostics for Renewable Energies (CaDRE), a tool developed by GIZ, the International Renewable Energy Agency (IRENA), US National Renewable Energy Laboratory (NREL) and I*nstituto para la Diversificación y Ahorro de la Energía* (IDEA).

Meetings were held with 15 organisations (government agencies, development agencies, finance institutions, training institutions, and others); discussions held with over 40 persons in the sector; 31 responses received from the online self-assessment exercise and 4 case studies completed including Denmark, Morocco, Uruguay and USA (Ormat geothermal VRE tracking technology) as part of this assessment.

It was found that, in relative terms, Kenya's VRE development is unique in several aspects including: i) a very liberal approach to take-or-pay based PPAs for VRE with little to no countermeasures, ii) the largest single power generator in terms of installed capacity is based on VRE, iii) wind is treated as the baseload capacity (must-run) thereby making the electricity generation percentage from VRE in Kenya to be much more than the installed 15% share of VRE. The last aspect contrasts the experience in countries like Germany whose share of VRE is more than 40% of the total installed capacity but the actual energy generated from VRE only accounts for about a quarter of the total electricity generated. From the Least Cost Power Development Plan (LCPDP) the proportion of VRE in Kenya is expected to rise to 26% by 2024.

The recent integration of an additional 310 MW of wind and 50 MW of solar PV to the grid has introduced unprecedented challenges in power system operations. Not only are these resources hard to plan for and utilize, but the problem is also compounded by systemic challenges that can be summarized as: i) limited forecasting capabilities, ii) constrained dispatch order, iii) weak distribution and transmission network, iv) minimal operating reserves and v) limited automation in generation control. However, these challenges are primarily a result of inconsistent electricity sector development planning processes that have led to an increase in supply capability not currently matched with demand. In addition, a significant proportion of the additional capacity is and will be from VRE.

Agencies under the Ministry of Energy employ a total of 16,047 staff, of which 12,304 (77%) are male and 3,743 (23%) are female.

#	ORGANIZATION	MALE	FEMALE	TOTAL	#	ORGANIZATION	MALE	FEMALE	TOTAL
1	Kenya power	8712	2281	10993	**6**	EPRA	92	51	143
2	GDC	716	308	1024	**7**	KenGen	1986	598	2584
3	KETRACO	399	158	557	**8**	Ministry of Energy	241	133	374
4	NuPEA	35	23	58		**Total**	**12304**	**3743**	**16047**
5	REREC	123	191	314					

At an individual level, close to half of the respondents of the self-assessment survey mentioned technical challenges rather than human capacity challenges as being the main barrier to the effectiveness. 68% of all respondents have a post graduate degree implying that the staff in charge of VRE issues across the agencies are highly qualified (academically). However, most of them earned their qualifications prior to having to deal with VRE. They will need capacity development in order to upgrade their skills to effectively deal with the new challenge of integrating VRE into the existing electrical system. Again, almost half felt that the country was not adequately prepared to deal with the current and projected contribution of VRE into the electricity mix.

At the **organizational level**, the assessment reviewed the agencies against key roles across the VRE origination, integration and operation spectrum. The results show that roles that need strengthening include:

- Mainstreaming VRE into long-term energy planning
- Implementation, monitoring, and evaluation of VRE
- Financial and economic analysis of VRE plants
- Simulations of the impact of VRE on the grid (load flow analysis, capacity value forecasting errors, etc.)

RATING: Red = 3, Amber = 2, Green = 1 and White = 0

1 – MoE, 2 – EPRA, 3 – GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 – Kenya Met Dept., 10 – Executive/Legislature

	ORIGINATION - KEY ROLES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**SCORE**
1	Policy and regulation formulation											1.0
2	Energy planning and modeling											1.0
3	Mainstreaming VRE into long-term energy planning & modeling											3.0
4	Implementation, monitoring and evaluation											3.0
5	Technical and financial review of proposals (EoI and proposal)											2.0
6	Renewable energy resource analysis											2.0
7	Transmission and distribution planning											2.0
8	Training and sectoral capacity development											3.0
9	Research and development											2.8
	TOTAL	**17.0**	**13.0**	**10.0**	**14.0**	**13.0**	**11.0**	**12.0**	**16.0**	**0.0**	**4.0**	
	TOTAL/ ROLE	**2.1**	**2.2**	**2.0**	**2.0**	**1.9**	**1.8**	**2.0**	**2.3**	**0.0**	**2.0**	

1 – MoE, 2 – EPRA, 3 GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 - Kenya Met Dept., 10 – Executive/Legislature

	INTEGRATION - KEY ROLES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**SCORE**
1	VRE Resource forecasting											3.0
2	Financial and economic analysis of plants											2.0
3	Technical analysis of VRE plants											2.3
4	Transmission system scenario analysis											2.0
5	Ancillary services requirements analysis											1.0
6	Simulations (Load flows analysis, capacity value forecast errors, etc)											3.0
7	Grid Integration studies											2.3
	TOTAL	**0**	**11**	**0**	**11**	**10**	**3**	**0**	**10**	**0**	**0**	
	TOTAL/ ROLE	**0**	**2.75**	**0**	**2.2**	**2**	**3**	**0**	**2**	**0**	**0**	

1 – MoE, 2 – EPRA, 3 GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 - Kenya Met Dept., 10 – Executive/Legislature

	OPERATIONS - KEY ROLES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**SCORE**
1	Advanced forecasting (weather)											3.0
2	Advanced forecasting (plant power)											3.0
3	Sub-hourly dispatch and intra-hourly scheduling											2.0
4	Contingency analysis, congestion management and economic dispatching											2.0
5	Storage and AGC operations											2.7
6	Operations and maintenance of VRE plants (e.g. Garissa Solar)											2.5
7	Impact of VRE plants on the existing firm capacity plants											3.0
		0	**0**	**0**	**14**	**6**	**12**	**0**	**0**	**3**	**0**	
	TOTAL/ ROLE	**0**	**0**	**0**	**2.8**	**2**	**3**	**0**	**0**	**3**	**0**	

At the system level, the main recommendations were that there is a need for a centralized data-driven coordinating process for onboarding all power producers – independent and public. This process should be driven by realistic demand forecasting. Second, the policy implementers should be better equipped to effectively communicate potential results and consequences of political decisions that do not align with the formal energy planning processes, including the LCPDP.

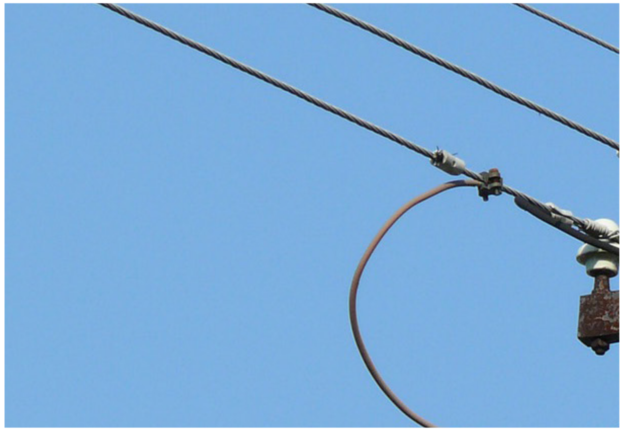
The key messages from this assessment are:

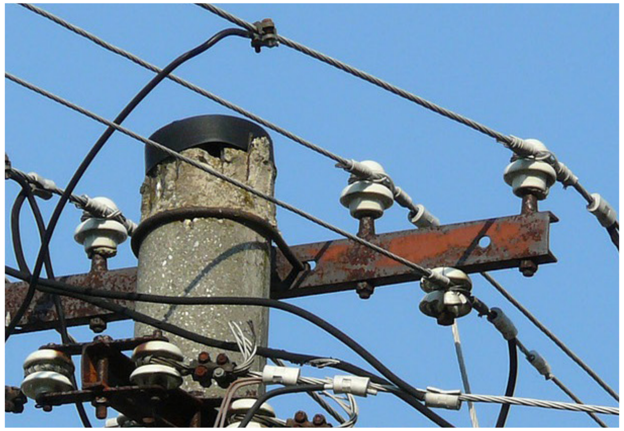
1. Technical capacity gaps are more critical than the human capacity gaps: Although there are several opportunities to strengthen the human capacity to manage and plan for VRE, many of these

efforts will have to be matched by investments in technical solutions. For example, training in the operation of AGC systems without a functional AGC system will not improve the current situation. Critical technical improvements, for example, expanding the capability and capacity of the current spinning reserves will significantly reduce the challenges of managing imbalances due to VRE. Human capacity is still needed, though to make decisions on what technical devices are required for effective system operations and to operate the new devices after installation.

2. Weakest link is at VRE origination: Although adequate effort is put in planning through, among others, the LCPDP process, there is a mismatch in proposed plans and actual implementation. This is the point where the policy implementers handshake with the policymakers and executive with the former driven by technical and economic considerations while the later by political ones. There are incidences where the two are aligned, but rarely does this occur.
3. Kenya's VRE situation is unusual: Relative to other countries that have comparable proportions of VRE, Kenya's case is unusual in that: VRE is treated as baseload supply due to the structure of the PPAs; generation entities carry out interconnection studies instead of the off-taker/grid operator; the largest single national generator is VRE based; 98% of all the current grid connected VRE generators is in one location which raises the system's vulnerability.
4. Support to the National Control Centre and the national utility is both critical and urgent: Being the client-facing agency of the electricity sector, Kenya Power faces disproportionate criticism and scrutiny as far as the quality of supply is concerned. The sector actors who have a better understanding of the interconnectedness of agencies should coalesce around and support the utility. The utility is the custodian and co-signatory to all PPAs and the current power system operator in charge of managing and guaranteeing system reliability, yet other agencies manage other crucial components that contribute to this reliability. For instance, KETRACO is tasked with building and maintaining transmission infrastructure to ensure effective power evacuation from generating entities, which ultimately affects system reliability.

This report is part 1 of 2 and outlines the human capacity needs assessment. The second part of the report, part 2 of 2, outlines a human capacity development strategy based on this assessment.





1.INTRODUCTION

1.1 Background

The centralized interconnected and off-grid connected systems in Kenya had a total installed capacity of 2,678.8 MW and 31.8 MW respectively as at 31st January 2019. This includes the recently commissioned 310 MW Lake Turkana Wind Power Project (LTWP) and 50 MW Rural Electrification and Renewable Energy Agency (REREC) Garissa Solar PV Plant. These additions and others have raised the contribution of VRE to the national installed capacity from 0.3% in March 2013 to 14.6% in January 2019 (see Table 1). With this comes the need to create systems that can effectively manage the variability of supply, especially for wind and solar. Limited predictability and continuous variability in supply present challenges in balancing supply and demand, which could negatively impact the reliability and quality of supply. Although power system planners and managers have had to contend with variability and uncertainty, these Variable Renewable Energy (VRE) sources pose a new and distinct challenge.

Within this context, the Ministry of Energy and GIZ are implementing the technical assistance project "Power system readiness for the integration of variable renewable energies (VRE)." This project will run from January 2019 to December 2023 and will cover four areas of cooperation: energy policy, energy planning, energy regulation, and energy operations. The main objective of this assignment is to "provide an overview of all stakeholders and their specific capacity needs for the further development of the VRE sector in Kenya." Managing VRE starts from project origination to integration and finally to operations. This study assesses the human capacity across these three stages while acknowledging that these are not the only types of gaps. This assignment deploys various methods, including the Capacity Needs Diagnostics for Renewable Energies (CaDRE), a tool developed by GIZ, the International Renewable Energy Agency (IRENA), US National Renewable Energy Laboratory (NREL) and *Instituto para la Diversificación y Ahorro de la Energía* (IDEA).

Table 1: Installed Capacity (Interconnected System) as of January 2019[1]

#	Generation Type	Mar-2013			Jan-2019		
		Installed (MW)	Effective (MW)	% Contribution (effective)	Installed (MW)	Effective (MW)	% Contribution (effective)
1	Hydro	816.2	766.9	46.4	826.2	805.0	30.5
2	Geothermal	251.4	244.9	14.8	663.0	655.0	24.8
3	Thermal (MSD)	466.0	447.5	27.1	716.3	691.8	26.2

> “The main objective of this assignment is to "provide an overview of all stakeholders and their specific capacity needs for the further development of the VRE sector in Kenya.”

[1]Data from MoE and EPRA public announcement made in August 2019 on a call for consultant to carry out a Power Markets Study

#	Generation Type	Mar-2013			Jan-2019		
		Installed (MW)	Effective (MW)	% Contribution (effective)	Installed (MW)	Effective (MW)	% Contribution (effective)
4	Thermal (Temp)	120.0	120.0	7.3	0.0	0.0	0
5	Thermal (GT)	60.0	27.0	1.6	60	55	2.0
6	Wind	5.1	5.1	0.3	336.0	335.5	12.7
7	Biomass	26.0	22	1.3	28.0	23.5	0.9
8	Solar	0.0	0.0	0	50.3	50.3	1.9
	Total	**1744.7**	**1633.4**	**100**	**2679.8**	**2616.1**	**100**

Renewables accounted for 24% of the total global electricity generation capacity in 2017 and this is expected to rise to 30% by 2023, with wind and solar PV projected to contribute 6% and 4% respectively[2]. The growth of renewables is primarily driven by international commitments to mitigate anthropogenic climate change, advancement in renewable energy technology options and increased cost competitiveness. Renewables are progressively attaining, and in some cases have attained, price and performance parity on the grid relative to traditional fossil fuels. With this comes the need to create systems that can effectively manage the variability of supply, especially for wind and solar. Although power system planners and managers have had to contend with variability and uncertainty, these Variable Renewable Energy (VRE) sources pose a distinct challenge. VRE systems are non-synchronous and characterized by variability, uncertainty, and location constraints. Effective integration of VRE will require non-conventional processes. Figure 1 shows the complexity introduced by VRE in the system operator's mandate of ensuring that electricity supply remains in balance with electricity demand. The impact of VRE is influenced primarily by the rate of integration, degree of variability, and percentage of contribution.

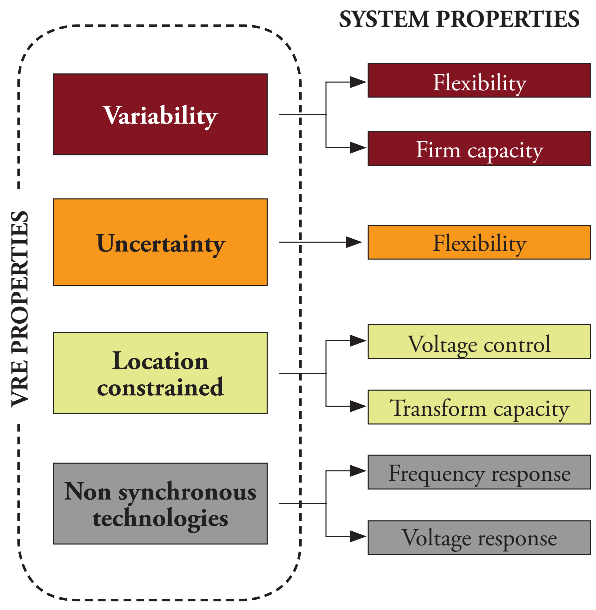


Figure 1: VRE Properties and Required System Properties

> "Renewables accounted for 24% of the total global electricity generation capacity in 2017..."

[2]IEA (2018) Renewables 2018, International Energy Agency, Paris
[3]Ministry of Energy (2018), Updated Least Cost Power Development Plan Study Period: 2017 - 2037

The current publicly cited peak demand of 1,882 MW was recorded on 14th February 2019. This has now exceeded 1,912 MW as of 31st October 2019 according to official records from KenGen. As outlined in the third Kenya Power medium-term plan (MTP III 2018-2022), a deliberate effort will be placed on promoting the role of renewable energy to create a climate-resilient, cost-effective electricity supply regime. Consequently, VRE is expected to further contribute to the electricity generation mix rising to 22.7% in 2030[3]. During this period wind power generation, for example, is expected to increase to 861.4 MW and solar power generation to 782.35 MW respectively.

1.2 Objectives of the Assignment

Within this context, the Ministry of Energy and GIZ are implementing the technical assistance project "Power system readiness for the integration of variable renewable energies (VRE)" whose objective is to improve the conditions for a system-friendly and cost-efficient integration of variable renewable energies into the Kenyan power grid. The project, which runs from January 2019 to December 2023, has four areas of cooperation: energy policy, energy planning, energy regulation and energy operations. The main objective of this assignment is to "provide an overview of all stakeholders and their specific capacity needs for the further development of the VRE sector in Kenya." To fulfill this objective, the implementation of this study makes the following considerations:

i. Guided by the ToR, this study focuses on the human capacity gaps in the management and operation of VRE while recognising that capacity needs assessment can be a broad exercise, covering several aspects such as institutional capacity, financial capacity, human capacity, infrastructural capacity, among others.
ii. Managing VRE starts from project origination to integration and finally to operations. This study assesses the human capacity across these three stages as shown in Figure 2 below.
iii. With the understanding that VRE technologies are part of a larger power system and do not function in isolation, this assessment and its findings discuss (inclusively) some aspects of power system operations that are not unique or specific to VRE. This was inevitable as some of the basic functions of system operation affect the effective operations of VRE.

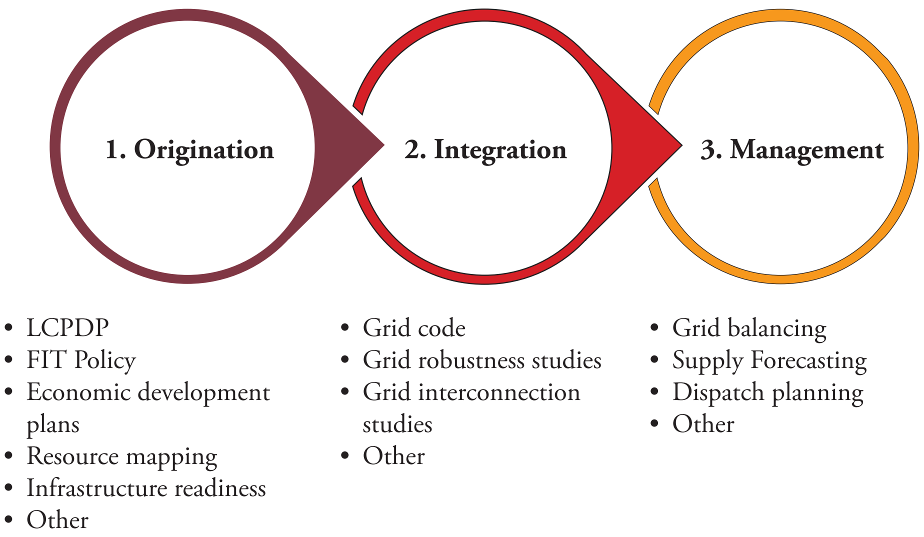


Figure 2: Stages in VRE Management in Kenya

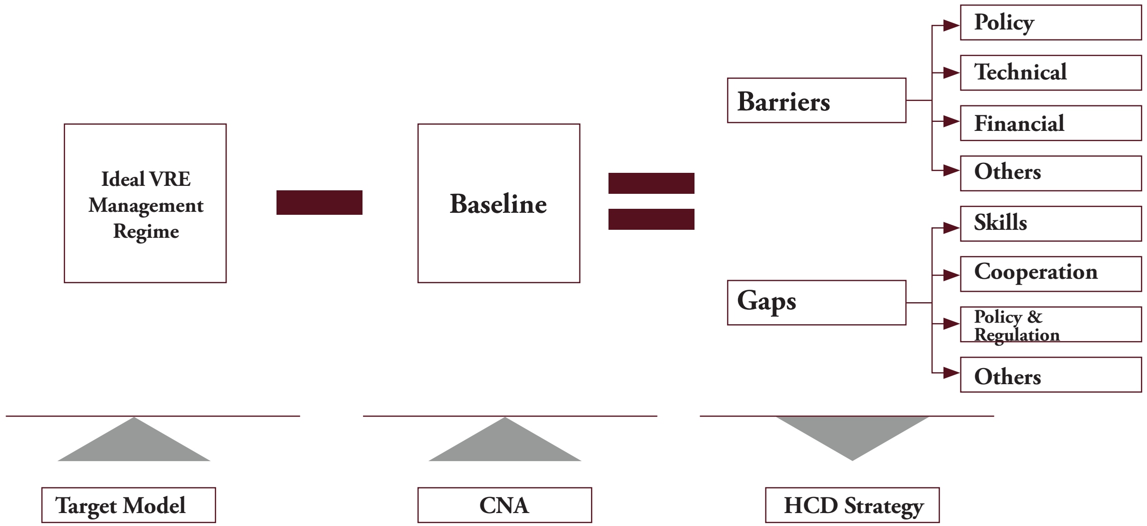
This assessment is the main input into developing a Human Capacity Development (HCD) strategy that will support the institutional and systemic advancement of the power system in relation to VRE management. As it will be explained below, this assignment deploys various methods including the Capacity Needs Diagnostics for

Renewable Energies (CaDRE), a tool developed jointly by GIZ and the International Renewable Energy Agency (IRENA), the US federal National Renewable Energy Laboratory (NREL) and *Instituto para la Diversificación y Ahorro de la Energía* (IDEA) of Spain. This tool presents a comprehensive approach to analyse existing capacity, predict future capacity needs and design strategies to develop the human capacity to the desired level. The main deliverables from this study are a capacity needs assessment strategy (inception report), a detailed capacity needs assessment report detailing the findings, and a human capacity building strategy.

1.3 Approach and Methodology

This study carried out a partial qualitative CaDRE study, which is based on consultations with GIZ and MoE, is in line with the ToR because of the relative maturity of the Kenya VRE sector and the time constraints of the study period. The approach in conducting this assignment started by defining the ideal VRE management regime (target setting), followed by a baseline assessment and completed by extracting a human capacity development strategy, as illustrated in Figure 3 below.

Figure 3: Summary of the approach



These steps are adapted from the CaDRE handbook and include:

i. Identification of the ideal aspects of renewable energy deployment. This step involved analysis of existing literature (case studies) and the in-country context within which VRE is implemented.

ii. Diagnostics to establish the baseline human capacities and related strengths and weaknesses in the target institutions. Comparing the baseline capacities against the target model will determine and isolate the capacity gaps and barriers limiting the VRE sector.

iii. Development of an HCD strategy based on the gaps and barriers as the basis of providing recommendations for capacity building in the sector.

iv. To ascertain the baseline and undertake the capacity needs assessment, we employed desk research, consultative meetings, and key informant interviews, as indicated in Figure 4.

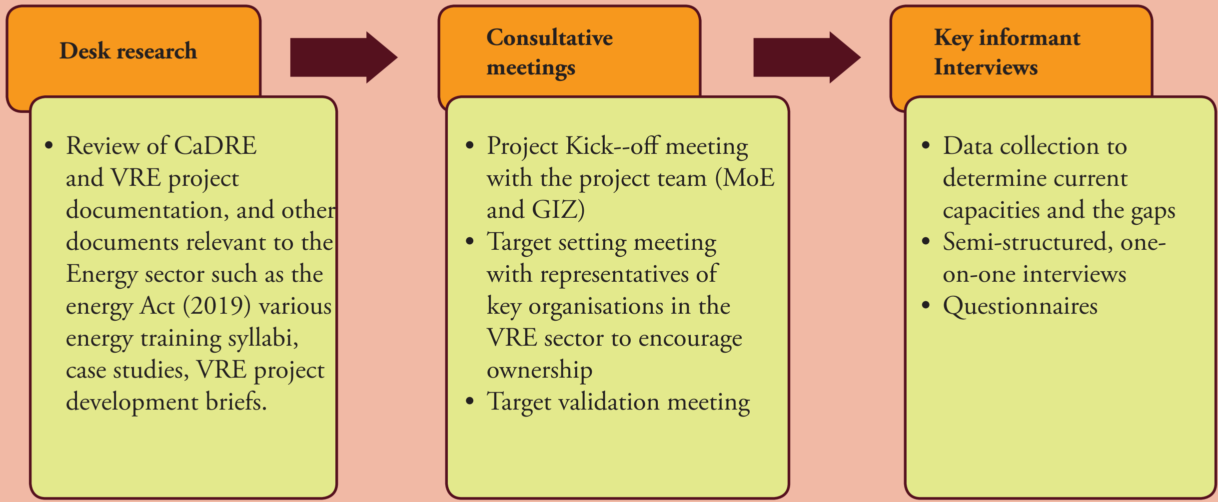


Figure 4: Summary of Methodology

The desk research phase involved an extensive review of CaDRE, IRENA reviews of VRE, the Energy Act (2019), various energy training syllabi, a country case study covering Denmark, Uruguay, Morocco, and the United States of America, and other documents relevant to the energy sector.

Consultative meetings held include, i) inception meeting with GIZ, ii) project kick-off meeting with GIZ and MOE, iii) target setting with the VRE committee, and iv) target validation with the VRE committee. Additionally, face-to-face and telephone interviews were held with key informants based on the list of stakeholders indicated in Figure 5. Representatives of the core organizations and implementing agencies whose roles directly impact VRE management were sent an online, anonymous self-assessment survey. The survey sought to gauge training and education level, work load, training needs, and infrastructure needs to enhance their VRE functions.

In summary, meetings were held with representatives of 15 organisations (government agencies, development agencies, financial institutions, training institutions, private sector, and others); discussions with over 40 persons in the sector; 31 responses received from the online self-assessment exercise and 4 case studies were completed including Denmark, Morocco, Uruguay and USA (Ormat geothermal VRE tracking technology).

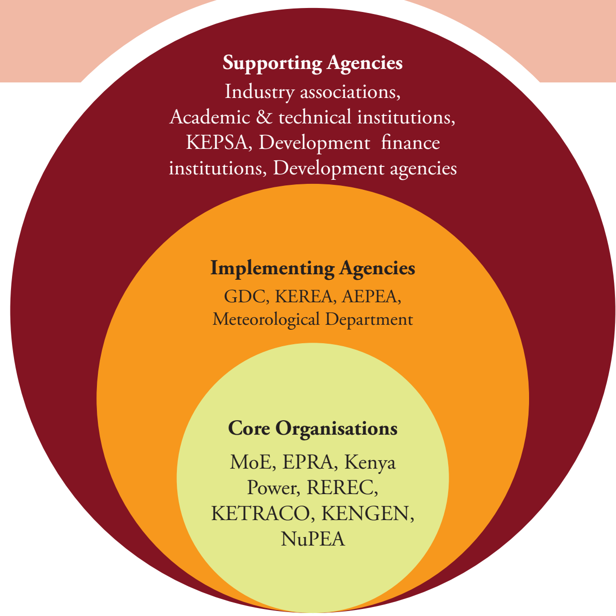


Figure 5: Non-exhaustive List of VRE Stakeholders in Kenya

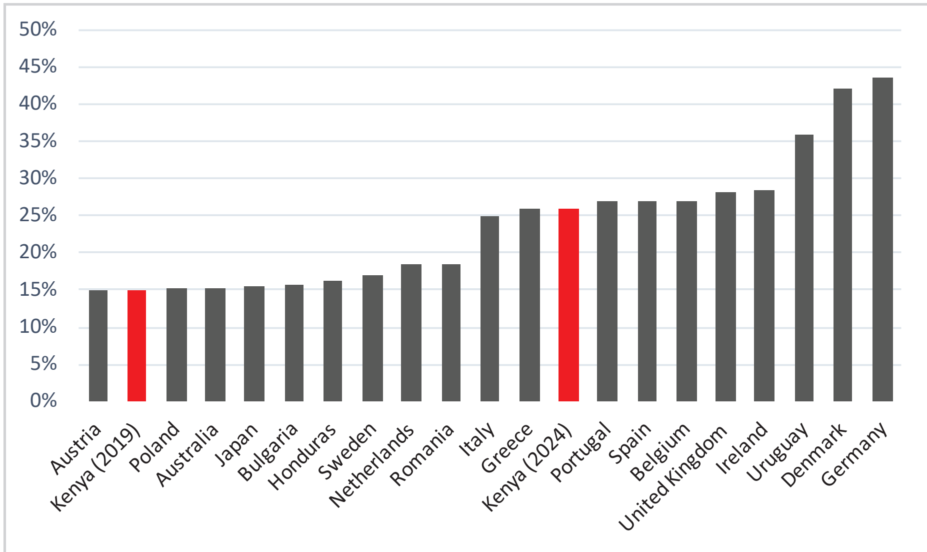
2. State of VRE in Kenya

2.1 Installed capacity

Kenya is richly endowed with renewable energy resources which now contribute up to 90% of the electricity generated and distributed through the central grid network[4]. Over the years, the share of installed capacity from VRE has increased significantly from 0.3% in 2013 to 14.6% in January 2019 and expected to rise to 26% by 2024 according to the Least Cost Power Development Plan (LCPDP). Germany and Denmark top the list of countries with the highest VRE proportions with other significant players highlighted in Figure 6. Notably, Uruguay has realized this increase in the last 10 years.

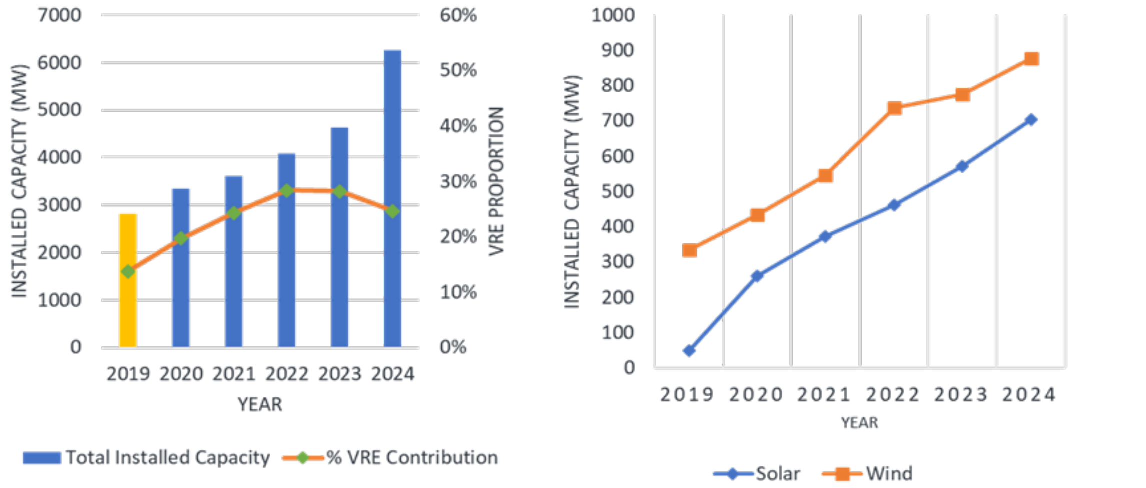
In relative terms, Kenya's VRE development is unique in several aspects including: i) a very liberal approach to take-or-pay based PPAs for VRE with little to no countermeasures, ii) the largest power generator in terms of installed capacity is based on VRE, iii) wind is treated as the baseload capacity (must-run) thereby making the electricity generation percentage from VRE in Kenya to be much more than the installed 15% share of VRE. The last aspect contrasts with countries like Germany whose share of VRE is more than 40% of the total installed capacity, but the actual energy generated from VRE accounts for about a quarter of the total electricity generated[5]. Additionally, European countries have an extensive and robust grid interconnection spanning several countries, which strengthens system stability when integrating the variability from wind and solar.

Figure 6: Share of Electricity Generation From VRE (source: Global Status Report 2019)



[4]Total electricity from renewable energy varies from day to day but can go as high as 90% (discussions with EPRA, November 2019)
[5]REN21 (2019). "Renewables 2019 - Global Status Report". https://www.ren21.net/gsr-2019/

From the LCPDP, the proportion of VRE in Kenya is expected to rise to 26% in 2024 then levelize at about 23% of total installed capacity by 2030 with capacities for wind and solar estimated at 861 MW and 782 MW respectively. Going by the total capacity of projects expected to come online between 2018 and 2024 listed on the LCPDP (2017-2024), the greatest share of VRE will be realized in 2023, at 28% before it starts leveling off. The actual installed capacities are expected to reach 877 MW for wind and 703 MW for solar by 2024 as shown in Figure 7. Achieving this level requires an addition of more than 100 MW of both wind and solar every year for the next five years.



*Yellow bar displays actual capacity and the blue bars represent projected values

Figure 7: VRE Proportions and Installed and Projected Wind and Solar Capacities in Kenya

The 310 MW Lake Turkana Wind Project and the 25.5 MW KenGen Ngong Hills Project are the two grid-tied wind projects on the power system. Kenya has an area of close to 90,000 square kilometers with wind speeds of 6m/s and above[6]. There are plans to install 861 MW and 841 MW off grid-tied wind by 2030 and 2037, respectively. Some of the planned wind projects include Kipeto I and II (100 MW), Chania Green (50 MW), KenGen Meru I (80 MW), Aperture (50 MW), Prunus (51 MW), Ol-Danyat Energy (10 MW), Electrawinds Bahari (90 MW), KenGen Meru II (100 MW) and KenGen Meru III (220 MW).

The Strathmore University (0.25 MW) and the Garissa plant (50 MW) are the two grid-tied solar PV projects currently operational. In the LCPDP (2017-2037), solar PV is expected to contribute to 10.8% (782 MW) and 8.6% (852 MW) of installed capacity in 2030 and 2037 respectively. The pipeline of solar PV to be connected to the grid include Marcoborero (2 MW), Kopere (40 MW), Alten Malindi (120 MW), Quaint-Kenergy (50 MW), Eldosol (40 MW), Makindu Dafre Rareh (30 MW), Gitaru (40 MW), Hanan Green Millenia (90 MW), Sayor Izera (30 MW), Belgen – Tarita Green Elgeyo Marakwet (80 MW), Belgen – Tarita Green Isiolo (50 MW) and Asachi Astonfield (81 MW). Table 2 indicates planned VRE projects by 2037.

[6] Government of Kenya, Updated Least Cost Power Development Plan, 2017-2037

#	Developer	Type	Capacity (MW)
1	Kipeto I & II	Wind	100
2	Chania Green	Wind	50
3	KenGen Meru I	Wind	80
4	Aperture	Wind	50
5	Prunus	Wind	51
6	Ol Danyat Energy	Wind	10
7	Electrawinds Bahari	Wind	90
8	KenGen Meru II	Wind	100
9	KenGen Meru III	Wind	220
		Wind Total	**751**
#	**Developer**	**Type**	**Capacity (MW)**
10	Marcoborero	Solar	2
11	Kopere	Solar	40
12	Alten Malindi	Solar	120
13	Quaint-Kenergy	Solar	50
14	Eldosol	Solar	40
15	Makindu Dafre Rareh	Solar	30
16	Gitaru	Solar	40
17	Hanan Green Millenia	Solar	90
18	Sayor Izera	Solar	30
19	Belgen – Tarita Green Elgeyo Marakwet	Solar	80
20	Belgen – Tarita Green Isiolo	Solar	50
21	Asachi Astonfield	Solar	81
		Solar Total	**653**

Table 2: Planned Wind and Solar Projects by 2037

[7]Giebel, C., et al (2016) Wind Power forecasting: IEA Wind Task 36 and future research issues, Journal of Physics: Conference Series 753 (2016) 032042

2.2 Impacts of VRE on the Power System

To maintain high levels of reliability and stability, power system operators must balance supply and demand for power. The integration of an additional 310 MW of wind and 50 MW of solar PV to the grid has introduced unprecedented challenges in power system operations. Not only are these resources hard to plan for and utilize, but the problem is compounded by a weak transmission and distribution network. The categories of challenges can be summarized as:

2.2.1 Limited Forecasting Capabilities

Power output forecasting is critical for effective operation of VRE as this influences the dispatch planning, scheduling plan, real-time balancing and day-on-day reserve requirements. This is generally a day-ahead forecast built on auto-regressive statistical or other machine learning models that simulate the power output (e.g. in the case of wind) based on wind speeds, directions, temperature, atmospheric stability and other measures[7]. Reliable forecasting reduces extra operational costs and improves system reliability. Large VRE generators are required to provide daily power output forecasting. The experience so far has revealed serious concerns with the current capacity for forecasting, which in turn has compromised the reliability of the data received by the National Control Centre. In extreme cases, as shown in Figure 8 and Figure 9, the forecast data can be completely unreliable or misleading. There are no penalties for unreliable forecasting or incentives to improve the accuracy.

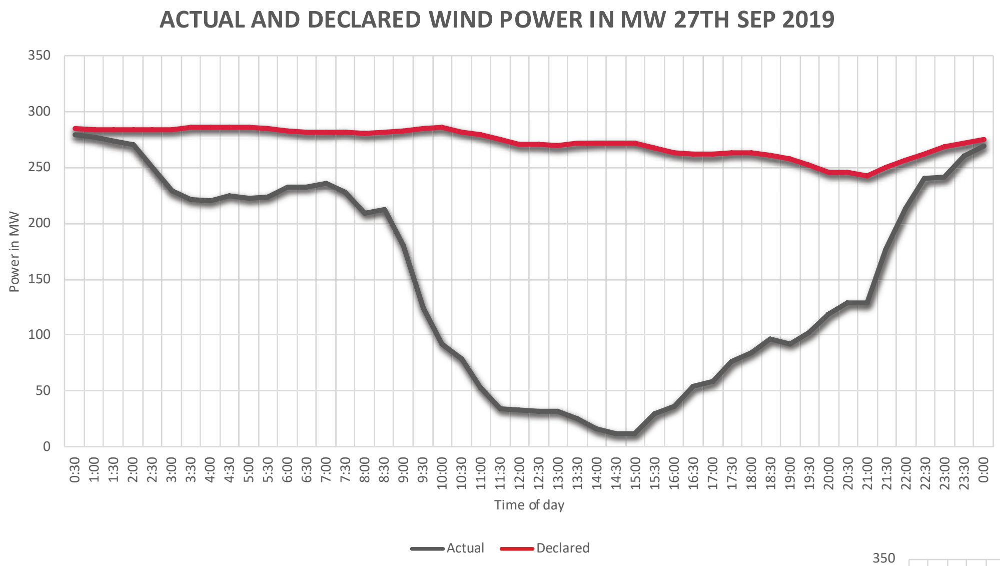


Figure 8: Overestimation – Actual and Declared Wind Power (LTWP), Kenya Power, October 2019

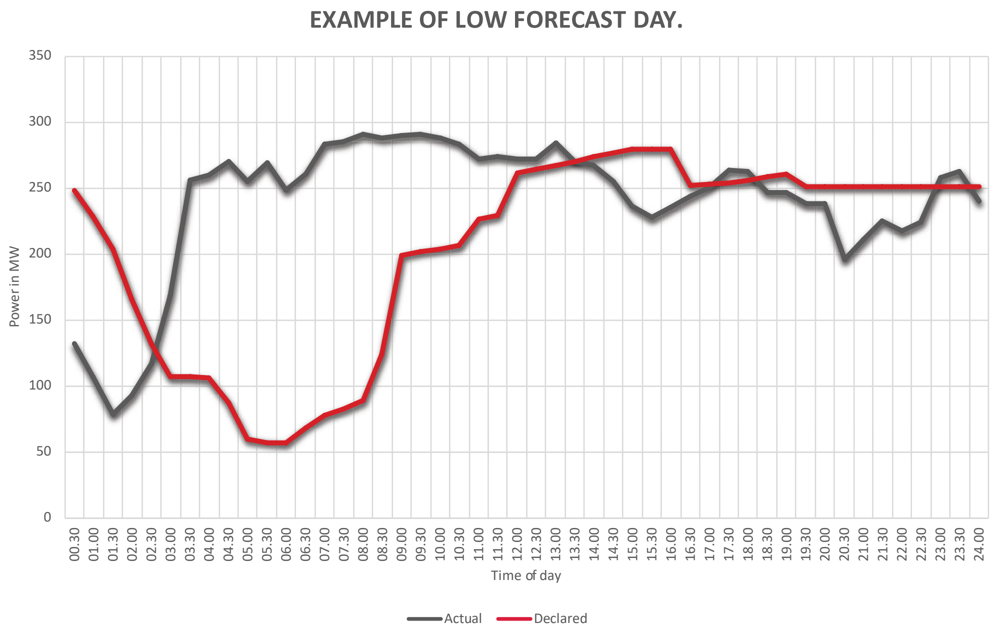


Figure 9: Underestimation – Actual and Declared Wind Power (LTWP), Kenya Power, October 2019

2.2.1 Limited Forecasting Capabilities

The two largest sources of VRE generators, LTWP and REREC Solar PV Garissa Project, are structured on a take-or-pay basis under their respective Power Purchase Agreements (PPA). Although the project team did not have access to the details of the PPAs, it was evident from the discussions with Kenya Power that the least cost option based on the structure of the PPA is to have the LTWP on a must-run basis (see Table 2), which essentially makes its operation comparable to a baseload supply. The result is that in case of a surplus supply or limited demand, other baseload power sources including geothermal and large hydro must be curtailed. Additionally, the fluctuations in the output of these resources result in sudden and unscheduled turning on and off other generators within short recurrent periods leading to increased wear and tear of the generators. Operating wind as the core part of the baseload supply is highly unusual.

> "Operating wind as the core part of the baseload supply is highly unusual."

Table 3: List of Top Ten Generators on the Merit Order – LTWP Listed as First (October 2019)

	Document #	KP1/3C.1/QMS/WI/03					
	Subject	KPLC MERIT ORDER RUNNING FOR OCTOBER 2019 BASED ON COSTS FOR SEPTEMBER 2019					
Station	Variable Energy Cost	Fuel Cost	Capacity/Deemed Cost converted to energy at Contr. Load Factor	Forex Adjustment Charges	Total Gen. cost	Total Variable Cost	Merit Order Based on Variable Cost
	(A)	(B)	(C)	(D)	(A+B+C+D)	(A+B)	(A+B)
	(KSH/KWH)	(KSH/KWH)	(KSH/KWH)	(KSH/KWH)	(KSH/KWH)	(KSH/KWH)	(KSH/KWH)
	1	2	3	4	5	6	7
LTWP 1	0.000	0.000	9.779	0.000	9.779	0.000	1
Major Hydros	0.084	0.000	2.520	0.570	3.174	0.084	2
Olkaria II	0.111	0.000	3.314	0.056	3.480	0.111	3
Olkaria V	1.120	0.000	0.000	0.000	1.120	1.120	4
Olkaria I	2.424	0.000	0.000	0.000	2.424	2.424	5
Orpower 4 Plant IV	3.061	0.000	7.199	0.000	2.424	3.061	6
Orpower 4 Plant III	3.061	0.000	7.199	0.000	10.260	3.061	6
Orpower 4 Plant II	3.061	0.000	7.199		10.260	3.061	6
Orpower 4 Plant I	3.062	0.000	7.219		10.260	3.062	7
Olkaria I AU	3.151	0.000	3.188	0.247	10.281	3.151	8
Olkaria IV	3.151	0.000	3.528	0.287	6.587	3.151	8
LTWP 3	4.889	0.000	0.333	0.000	4.889	4.889	9
Garissa Solar (REA)	5.699	0.000	0.333	0.000	5.699	5.699	10

2.2.3 Weak Distribution And Transmission Network

Although the total installed capacity now sufficiently exceeds peak demand, transmission capacity limits the supply of adequate power from the main generation centres to various regions in Kenya, especially to the Western Region. This often results in the importation of power from Uganda while curtailing local generation due to an inhibited transmission-distribution infrastructure. Plans are at advanced stages to expand the transmission infrastructure from Suswa to the Western Region, but until then, balancing power supply (especially in the period of increased generation and limited demand) to the Western Region is limited by the size of the transmission lines. This diminishes the flexibility of the National Control Centre to discharge power as needed to that region. The same case applied to the Coastal Region until the Suswa-Isinya-Rabai 400kV high voltage power line was completed.

2.2.4 Minimal Operating Reserves

Limited predictability and continuous variability in supply presents challenges in balancing supply and demand. Loss in a generating unit and changes in demand or supply can lead to an imbalance in an electric power system (see Figure 10 and Figure 11).

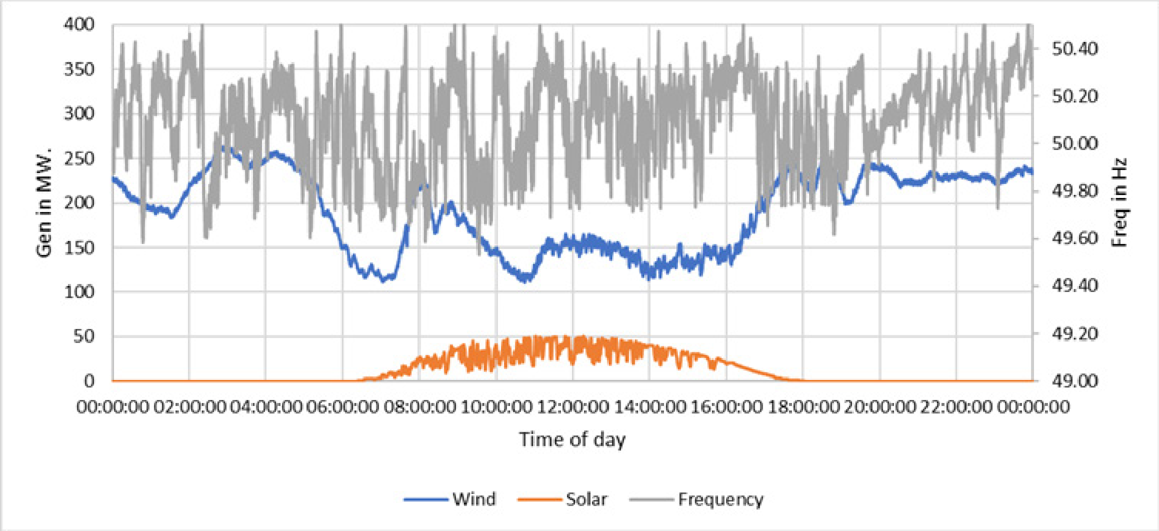


Figure 10: Effect of Intermittent Generation on Frequency (24 hours period) – November 2019

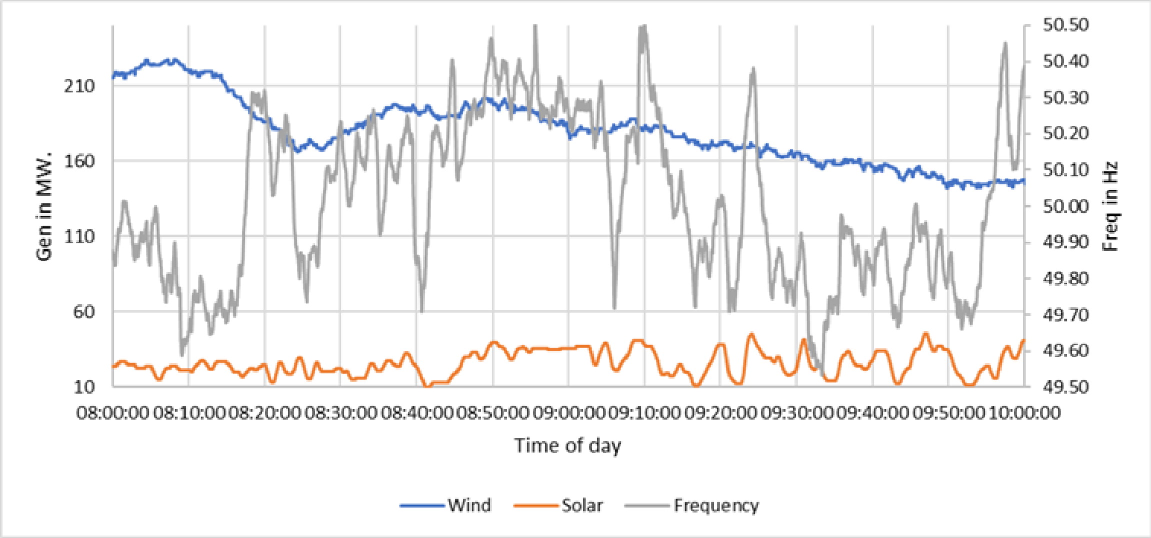


Figure 11: Effect of Intermittent Generation on Frequency (0800h – 1000h) – November 2019

To strengthen the system flexibility (ability to rapidly respond to such changes), operators would typically activate demand (during excess supply) or draw energy from standby sources that can be ramped up and down accordingly (during limited supply). The second action requires the availability of adequate operating reserves (type and capacity). NREL 2012[8] indicates that there are four main types of reserves, and these are described as follows:

Regulating reserves: "Capacity above or below scheduled generation used to correct the continuous, fast, frequent changes in load and generation and any differences from forecasted conditions. They correct variations within the shortest applicable market interval (between five minutes and one hour)". These types of reserves respond through Automatic Generation Control (AGC).

Spinning reserves: "Capacity available for assistance during rare, sudden events that require more severe balancing than that needed during normal conditions. The reserves must stabilize the frequency, return it to its scheduled level and ensure the system is brought back to a secure state."

Following reserves: "Capacity above or below scheduled generation used to correct anticipated imbalances in the system." These are like regulating reserves but have a slower response time because they correct anticipated changes rather than current imbalances. Following reserves are controlled manually.

Ramping reserves: "Capacity available for assistance during unexpected, infrequent, and severe events that are not instantaneous in nature."

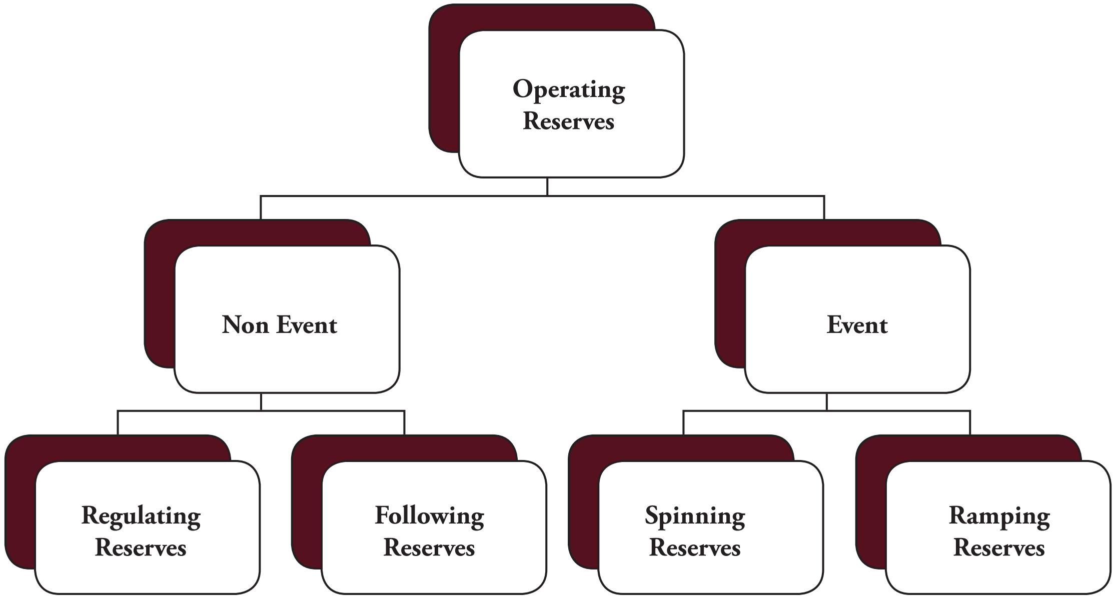


Figure 12: Types of Operating Reserves

Kenya has a 30% reserve margin (comparing peak demand versus installed capacity) but minimal spinning reserves estimated to be about 50 MW, and which can only be deployed through manual operations that involve system controllers calling station operators on a case by case basis. This is against a highly variable capacity of more than 380 MW, not accounting of other impacts on supply and demand that are non-VRE related.

2.2.5 Limited Control Automation

The National Control Centre operates a manual

[8]NREL (20120) Impacts of solar power on operating reserve requirements, National Renewable Energy Laboratory of the US Department of Energy, Colorado.

generation control system with controllers constantly calling station operators to adjust their output to correct for imbalances. There is need for Automatic Generation Control (AGC), which is a self-operating system adjusting for power output across multiple generators in response to changes in load. AGC systems enable power systems to meet the reliability criteria in an economical way. Maintaining system frequency is part of the reliability requirement, and there should be a stricter adherence to frequency deviations aiming at keeping the system frequency as constant as possible. With an increase in the contribution of VRE, there is now an urgent need to have an advanced control system that automatically manages the ramping up and down of power supply, and other related operations over short timeframes to guarantee proper frequency control. When done manually, as is the case currently, achieving economically efficient dispatch while maintaining reliability becomes harder.

2.3 VRE in Power Planning

Two policy instruments have been central in promoting the development of renewable energy in Kenya: the Feed-in-Tariff (FiT) policy and the LCPDP. The FiT focuses on smaller renewable energy projects providing fixed prices for the various technologies. The LCPDP, on the other hand, is a 20-year master plan on electricity generation and transmission with an emphasis on grid-based generation that is revised once every two years. More recently, the Energy Act 2019 was signed into law and this will determine the uptake of VRE and other renewables into the power system.

2.3.1 Feed-in Tariff Policy

The Feed-in Tariff (FiT) is a policy strategy aimed at increasing investment in renewable energy in Kenya by providing a pre-determined fixed price for a period. The first FiT policy in Kenya was developed in 2008 and covered the various renewable energy technologies including wind, small hydro, geothermal, solar, and biomass sources. The policy has been revised twice in 2010 and 2012, and currently provides a fixed price and a standardized PPA for different renewable technologies of up to 10 MW connected to the grid while those above 10 MW are considered on a case by case basis. This is except for geothermal, which has a minimum capacity of 35 MW. The FiT policy in Kenya has a provision for revision every three years from the date of publication by the FiT committee. The Energy Act 2019 provides the FiT system with the aim of catalysing electricity generation through renewable energy sources and reducing greenhouse emissions from energy supply. Under the Act, the FiT will be regulated by the Energy and Petroleum Regulatory Authority however, the Cabinet Secretary may on occasion make regulations for the administration and implementation of the FiT system. There are plans to replace the FiT policy with an auction system for solar and wind projects.

2.3.2 Least Cost Power Development Plan

The Kenya Least Cost Power Development Plan is a review of Kenya's energy sector providing guidance on sector status, generation expansion opportunities, transmission infrastructure, target network expansion as well as resource requirements for the expansion programme. The plan covers 20 years and is revised at least once every two years. The Technical Committee in charge of the reviews constitutes the key agencies in the energy sector including Ministry of Energy, Kenya Power and Lighting Company, Geothermal Development Corporation, Kenya Electricity Transmission Company, Kenya Electricity Generation Company, the Nuclear Power and Energy Agency and the Rural Electrification and Renewable Energy Corporation. Besides the energy agencies, other representatives are drawn from the private sector and public institutions such as Vision 2030 Secretariat and the Ministry of Devolution and Planning.

2.3.3 Energy Act Review

The 2019 Energy Act, adopted in March 2019, introduces various amendments to the Kenyan energy sector and consolidates the energy laws in the country. The Act also provides for national and county government functions relating to energy in alignment with devolution as outlined in the Kenya Constitution of 2010. The government is charged with developing the national energy policy, which has to be reviewed every 5 years and sharing an implementation report yearly. The government is also mandated to develop, publish and review the integrated national energy plans in respect of all energy sources to ensure delivery of reliable energy services at least cost. County governments are mandated with developing County Energy Plans in

consideration of the national energy policy and all energy supply options available. These plans, which are consolidated to form the integrated national energy plan, are expected to guide the selection of appropriate technologies and energy infrastructure investment to meet demand.

With plans to power the country from 100% green energy, the government demonstrates its commitment to these goals through the establishment of the Rural Electrification and Renewable Energy Corporation and a Renewable Energy Resource Advisory Committee. It gives legal effect to the renewable energy feed-in tariff policy that was first issued in 2008.

Renewable energy

While the Act does not explicitly distinguish between renewable energy and variable renewable energy, the provisions made regarding renewable energy are applicable to the sources classified in the latter. Energy Act 2019, unlike the repealed Energy Act 2006, covers renewable energy extensively outlining the authorities charged with its exploitation, development and promotion. The Act vests all unexploited renewable energy resources in the country in the national government. The cabinet secretary of energy is expected to conduct a resource assessment and prepare a resource map and renewable energy resources inventory that will be gazetted.

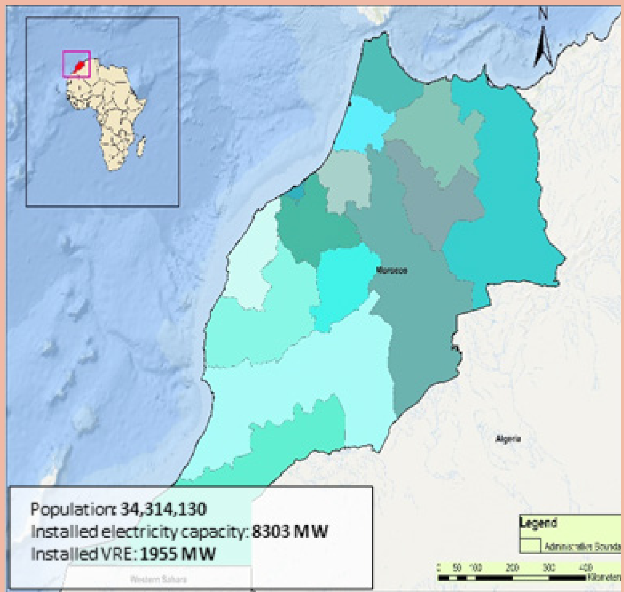
Renewable Energy Resource Advisory Committee

The Act also established an inter-ministerial renewable energy resource advisory committee which will be composed of representatives from the energy ministry, ministry of environment, and the national treasury. Other committee members will include the attorney general, KenGen, and GDC representatives. The committee is expected to advise the cabinet secretary on allocation and licensing of renewable energy resource areas as well as management and development of these resources.

“With plans to power the country from 100% green energy, the government demonstrates its commitment to these goals through the establishment of the Rural Electrification and Renewable Energy Corporation and a Renewable Energy Resource Advisory Committee.”

Case Study I – Morocco: Diversifying Generation Options

VRE installed capacity (MW)	% VRE	Independent system operator	Level of competition	Level of unbundling	Separate regulator
1955	10%	No	Monopoly	Vertically Integrated	Yes



Morocco's installed electricity capacity was 8303 MW as at 2016 according to the U.S. Energy Information Association (EIA). The VRE (wind and solar) installed as of Dec 2018 is 1955 MW according to International Renewable Agency (IRENA). Being the only North African country without its own oil resources, Morocco is a large energy importer. The country's main challenge is meeting the rising local energy demand without increasing its import costs. To achieve this, Morocco is pursuing an ambitious, cost-effective energy transition aimed at endowing the country with a sustainable, competitive and secure energy sector. The country launched the Integrated Wind Energy Program (IWEP) in 2010 to increase its renewable energy resource in the energy mix. The program is implemented by the country's electricity utility ONEE (Office National de l'Electricité et de l'Eau Potable) with the intention to increase the wind capacity from 280 MW in 2010 to 2 GW (14%) by 2020 and to 5 GW (20%) by 2030. IWEP sets the goal to establish a high level of expertise and strengthen R&D in order to benefit the technological and industrial sectors. To achieve these objectives, the government decided to create two dedicated governmental agencies: The Moroccan Agency for Sustainable Energy (ARME) that is in charge of implementing both wind and solar generation, and Moroccan Agency for Energy Efficiency (AMEE) which is tasked with implementing Energy efficiency initiatives.

The Moroccan government overhauled its existing legal framework in order to transform the sector with the goal of attracting the necessary investments to meet increasing demand. This entailed amendment of the sector legislation to allow for private investment and the introduction of the IPP (Independent Power Production) model in the electricity generation sector. The country decided to reduce the share of oil and hydro in power generation and to diversify fuel options with the increase of the share of coal and the introduction of natural gas. It also embraced new power generation technologies such as Concentrated Solar PV and wind energy. To do this effectively, LAW 13-09 (2010) was promulgated to liberalise and develop the renewable energy sector in Morocco. It allows private companies to produce and export electricity as long as they utilise renewable energy (solar, wind, geothermal, wave, tidal, biomass, waste and biogas). In addition to the change in policy, the country established the Institut De Recherche En Energie Solaire Et Energies Nouvelles (IRESEN) in 2011 to develop, coordinate and enhance the efficiency of research in RES, translating the national strategy into implementing and participating in the financing of R&D projects carried out by research institutions and by industrialists and exploiting and popularising the results of research projects.

Morocco's grid is interconnected with Spain and Algeria from where it imports some of its energy. The electricity imports are mainly from Spain due to the relatively low cost of electricity there. There are plans to interconnect the grid with Mauritania and Portugal to further increase grid stability. This is useful in reducing the system interruptions caused by VRE due to the added stability of a large interconnected grid despite changes in generation. Morocco can still invest in VRE. The reforms in the electricity sector have helped increase Morocco's energy security and reduce its dependence on electricity imports from Spain, coal imports from South Africa and oil imports from the OPEC.

3. VRE Development Cycle

Origination

These are the preliminary activities done before a power plant is constructed, commissioned and operated. The national government, through the Ministry of Energy (MoE) and its agencies, creates an enabling environment for private investors and public power producers to establish power plants. Currently MoE leads and coordinates the development and review of the Least Cost Power Development Plan (see Section 2.3.2). Elaborate energy sector modeling is carried out including the effect of current and proposed power plants on the grid infrastructure to inform the recommended number of proposed power plants.

Additionally, the document indicates recommended levels of VRE deployment among other energy sources. Proposed VRE power plants are reviewed under the Feed-in Tariff (FiT) process, though this is to transition to RE Auctions with the exception of biomass and small hydro to remain under the FiT process. Resource mapping is done at the origination stage of the development cycle and is also coordinated by the MoE. High resolution resource maps are generated and aid in the development and analysis of proposed power plants. Figure 9 indicates the process for developing a VRE powerplant encompassing both origination and integrations stages.

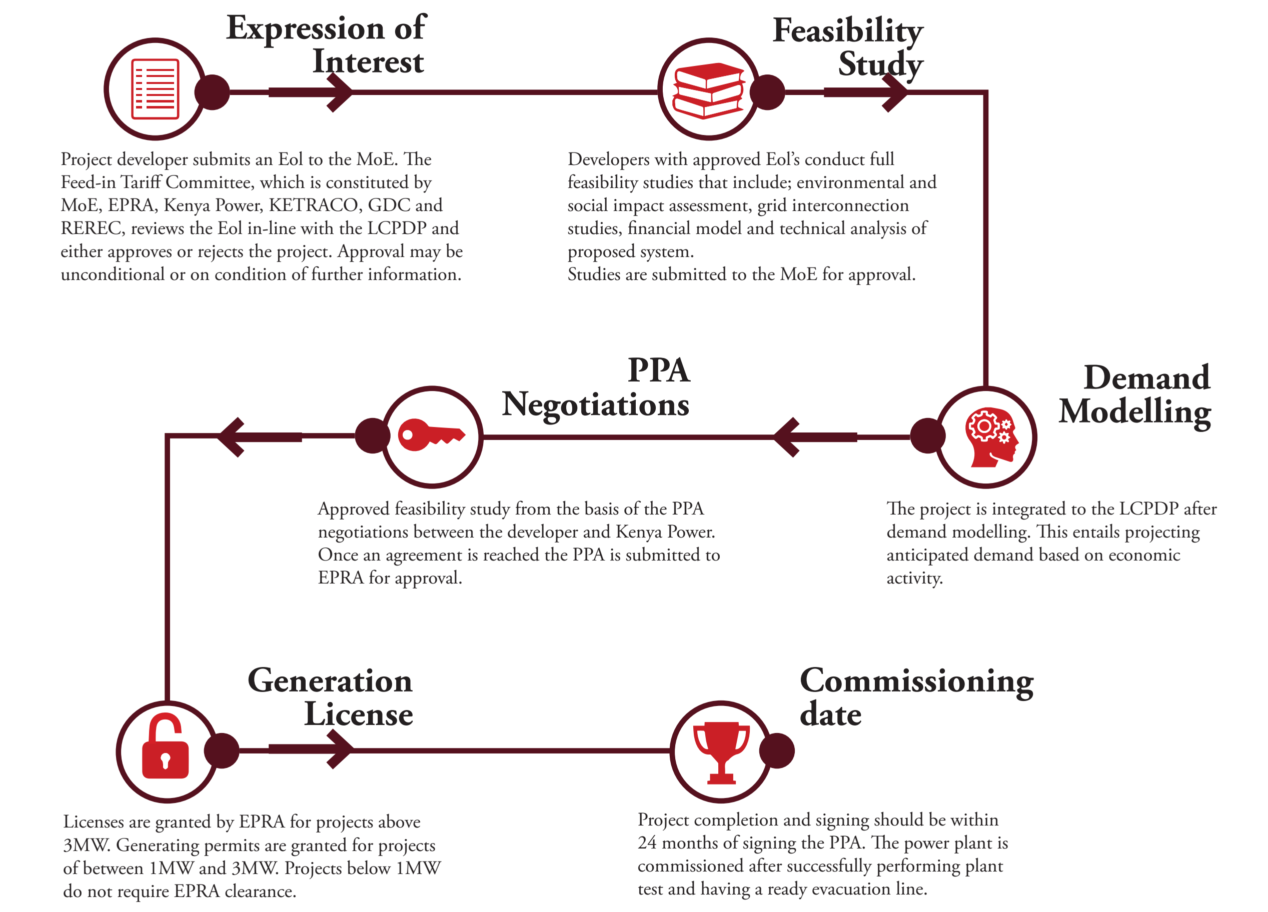


Figure 13: VRE Development Process

Integration

This involves the actions required to connect VRE powerplants to the off-taker through the national grid. This stage is closely linked to the origination stage as grid integration studies, technical and financial analysis and grid simulations feed into the energy sector modelling and planning at origination. At this stage grid integration studies are done at the individual project level with emphasis on the infrastructure required for the interconnection of the project to the larger grid.

Operation

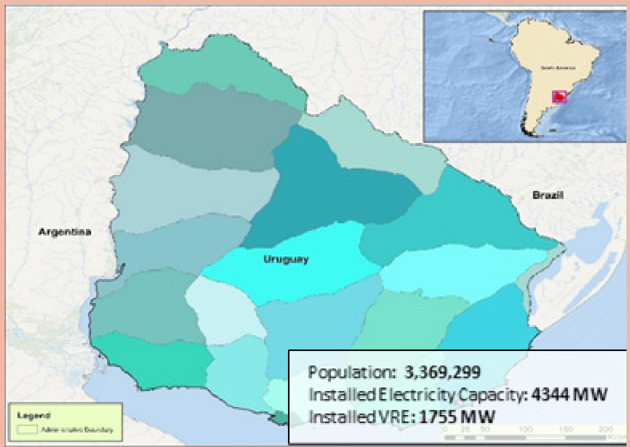
This entails the continuous management of grid-tied VRE powerplants output to the grid. This mandate falls on the system operator as the lead agency in scheduling and dispatching power plants as well as on VRE power producers and the weather forecasting agency. Responsive planning at the origination and integration level are key to an incident-free operation of VRE system in the electricity system. Best practice in efficient management of VRE within the national energy mix involves advanced weather and energy forecasting. Forecasts should be as close to the time of operation as possible to enhance the decision process of congestion management and economic dispatch. Modern grid operational planning systems such as the SimSEE developed domestically models VRE and conventional power plants output in system planning and dispatch up to one hour ahead of the operation, ensuring data-driven system control[9]. Operations also involve the appropriate and timely maintenance of VRE power plants by the power producers.

> “Forecasts should be as close to the time of operation as possible to enhance the decision process of congestion management and economic dispatch.”

[9]C. Cabrera (2018), Long-term Power Generation Capacity Expansion Planning and FlexTool Analysis: URUGUAY CASE STUDY, Ministry of Industry, Energy & Minerals

Case Study II – Uruguay: Developing a VRE Curriculum and Demonstration Farm

VRE installed capacity (MW)	% VRE	Independent system operator	Level of competition	Level of unbundling	Separate regulator
1755	40%	No	Retail Market Competition	Vertically Integrated	Yes



Uruguay has an installed electricity capacity of 4344 MW with around 80% of this capacity comprising of renewable energy. The energy sources are wind, hydroelectric power, fossil fuels, photovoltaics and biomass. Data from the National Administration of Power Plants and Electrical Transmissions (UTE) website shows that the installed VRE (wind and solar) capacity as of 2018 was 1755 MW which makes up almost half of renewable energy and 40% of the installed electricity capacity. Wind and solar generation as a market share grew from 1% in 2013 to over 40% in 2018 ranking the country 2nd in market share of wind behind Denmark. This quick progress is attributable to the Uruguay Wind Energy Program (UWEP), which created an enabling environment for renewable energy development. The UWEP was targeted primarily at strengthening existing institutional and human capacity by enhancing manpower, facilitating training, and streamlining intra- and inter-institutional processes.

To address the problem of lack of prior experience in dealing with variable generation, the state utility developed a demonstration wind farm and created a renewable energy technology curriculum at Uruguay's Universidad de la República to train its staff to integrate renewable energy sources into the grid. The utility also reached out to developers and investors to build their knowledge and address risk perceptions in the wind sector. Furthermore, UWEP also addressed the lack of specific information needed to initiate and develop wind energy in the country by implementing a sustainable wind measuring programme and executing supporting studies.

Useful grid network conditions favour the integration of variable generation enabling the country to manage such rapid wind and solar growth. Uruguay has a large amount of installed hydropower capacity, which complements the variable renewable generation due to its flexibility. The wind farms are also geographically spread across the country, which smoothens the variability of wind and solar due to change in weather conditions. Flexible back-up generation is also incentivised to balance the variability of wind power. The country's electricity grid is interconnected to Brazil and Argentina allowing it to export wind power surpluses. There was a synergic alliance among university research teams and government actors for the development of the technical core skills of the energy policy. This led to the development of wind maps and the domestic software development for prediction and monitoring of diverse energy sources in the electric grid (SimSEE).

Despite the success in wind and solar energy integration to the electric system, Uruguay has the most expensive electric power in South America. Even though residential electricity prices are now almost 20 percent lower than in 2010, the energy transition has not changed Uruguay's position in this regard. The guarantee that UTE will buy all the renewable energy generated causes over-generation which in turn leads to the high electricity tariffs.

4 Electricity Sector Players

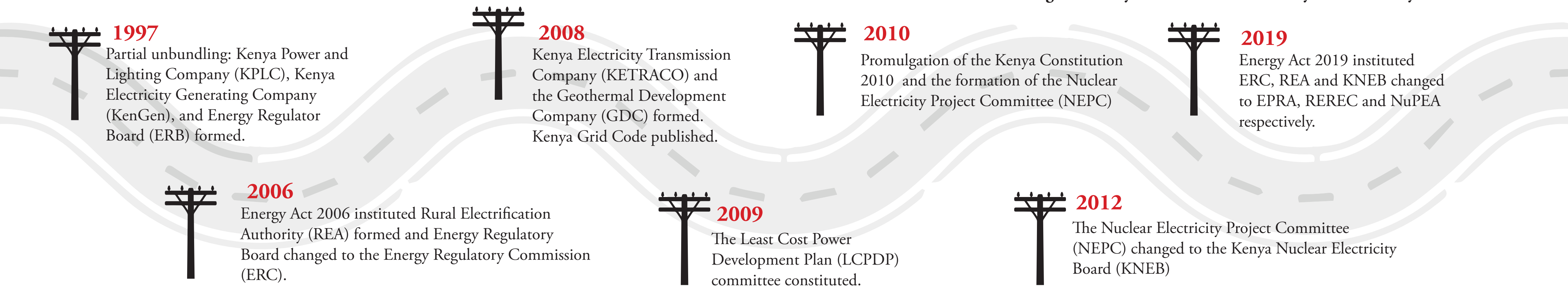
4.1 Overview

The Kenya electricity sector comprises of 7 major state agencies namely, Kenya Power, Kenya Electricity Generating Company (KenGen), Rural Electrification and Renewable Energy Corporation (REREC), Nuclear Power and Energy Agency (NuPEA), Kenya Electricity Transmission Company (KETRACO), Geothermal Development Corporation (GDC), Energy and Petroleum Regulatory Authority (EPRA) whose activities are coordinated by the Ministry of Energy. These agencies have various mandates in the electricity sector as outlined in the Energy Act 2019. The creation of these agencies is part of an electricity sector reform process, which started in the 1990s and sought to introduce structural transformation in the electricity sector.

The new paradigm for power sector organization comprised of four packages of structural reforms that include restructuring of the utility through full horizontal and vertical unbundling, creation of an independent regulatory entity, enabling private sector participation and introducing competition in power generation and distribution. The vertically integrated monopolies had the limitations of inefficient operations, growing need for government subsidies, financial constraints and government interference. Successful implementation of the reforms would bring about improved sector performance, customer orientation, good financial performance, improved efficiency and cost recovery of utilities, elimination of private management abuses and elimination of day to day political interference. Kenya was one of the first countries in Sub-Saharan Africa to institute market-oriented power sector reforms. These reforms have mostly been successful albeit with a few challenges.

Private sector participation in the main grid is largely at the power generation level and in the construction of transmission and distribution lines. With the Energy Act 2019, it is anticipated that there may be private sector participation in the largely Kenya Power controlled electricity distribution space. The figure below illustrates the electricity reform journey in Kenya over the last two decades.

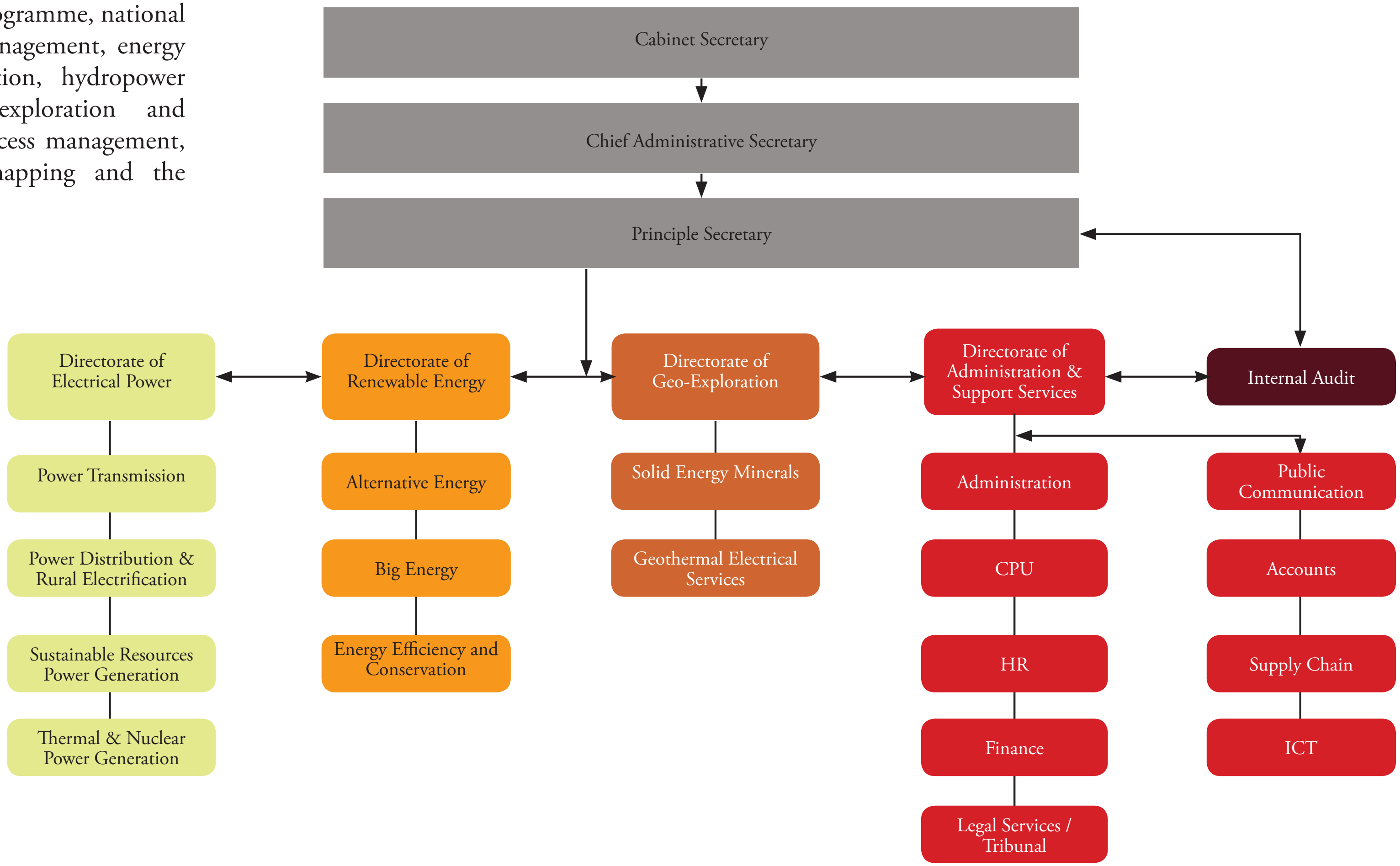
Figure 14: Key Reforms in the Electricity Sector in Kenya

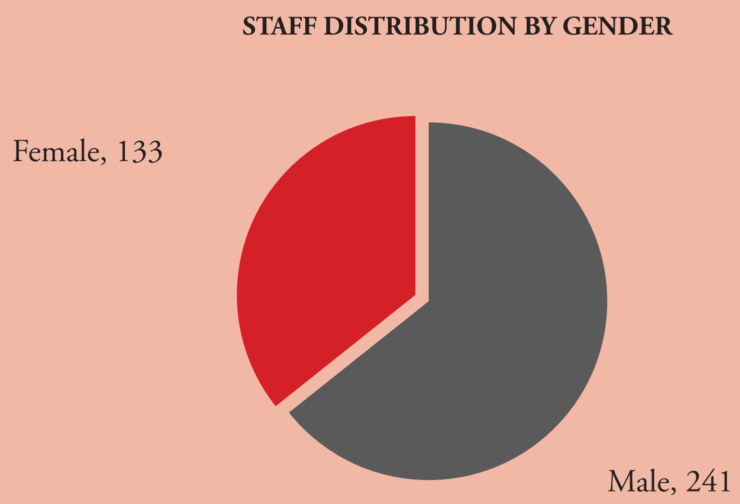


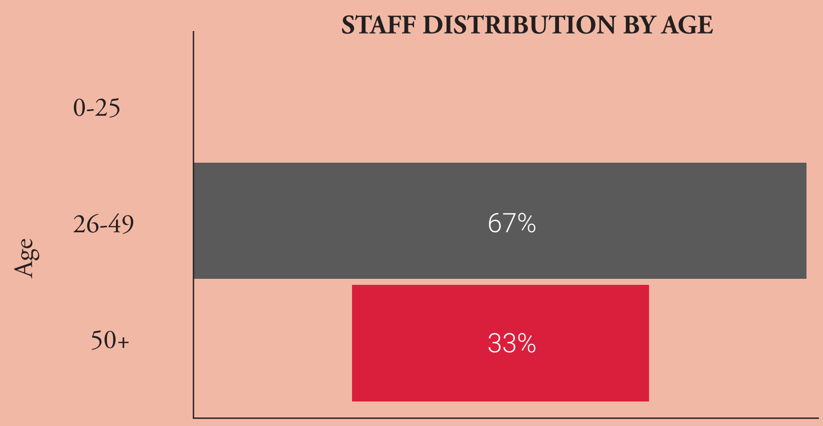
4.2 Ministry of Energy

The Ministry of Energy is mandated to develop and implement policies that are conducive to the growth of the energy sector in the country. Executive Order No.1 of 2018 defines the functions of the Ministry as: promotion of renewable energy, thermal power development, rural electrification programme, national energy policy development and management, energy regulation, security and conservation, hydropower development and geothermal exploration and development. In terms of VRE process management, the ministry oversees resource mapping and the implementation of the Least Cost Power Development Plan (LCPDP) through Feed-in Tariff (FiT). This involves coordinating the approval project Expression of Interest (EOI) and the detailed feasibility studies of prospective projects.

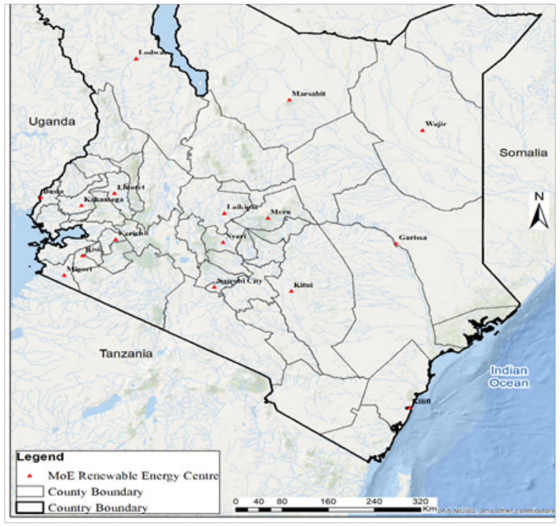
Organisational Structure







Company Demographics



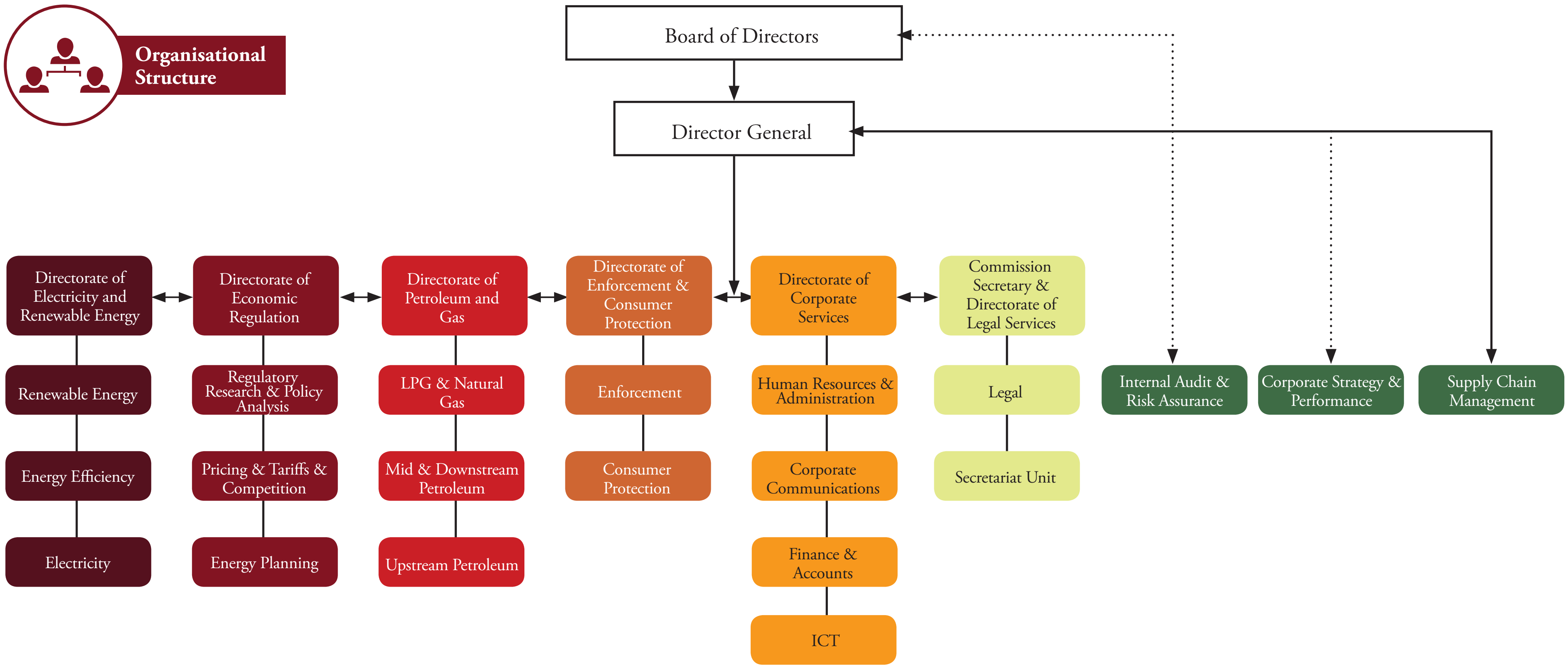
Highlights of the Stakeholder Meeting

The ministry is set to consolidate plans from utilities, county governments and other organisations to create an integrated national energy plan under the Energy Act (2019). This may be coordinated by the ministry through a working group constituted from EPRA, MoE and the other state agencies. County governments may require capacity building in relation to formulating energy plans. Research should be and will continue to be done by the state agencies to be coordinated by the MoE and possibly NuPEA. The Energy Act (2019) envisions two system operators, one for the transmission network and one for distribution. There is need to enhance communication between technocrats and the political class to manage political influence in developing energy plans.

4.3 Energy and Petroleum Regulatory Authority

Established under the Energy Act 2006 as the Energy Regulatory Commission (ERC) and later succeeded by the Energy and Petroleum Regulatory Agency (EPRA) through the Energy Act 2019, EPRA is mandated to regulate and monitor electrical energy, renewable energy and petroleum and related energy (e.g. coal and gas) with the exception of licensing nuclear facilities and regulating crude oil. EPRA issues licenses and maintains statistics of activities in the sub-sectors enumerated above.

Organisational Structure



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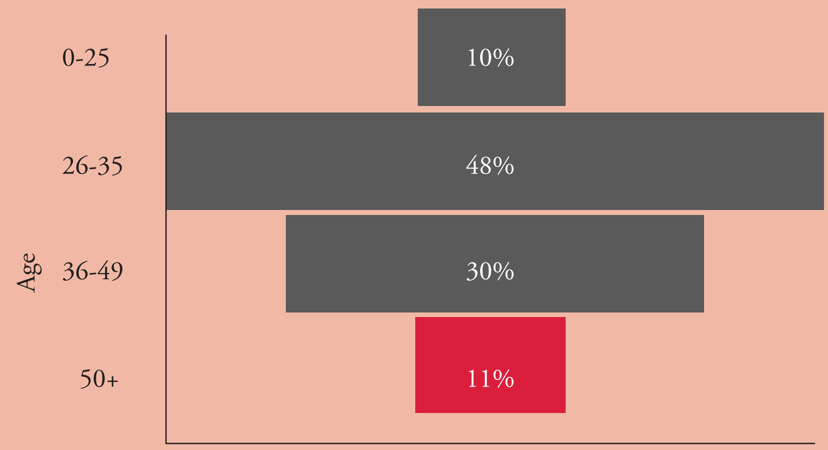
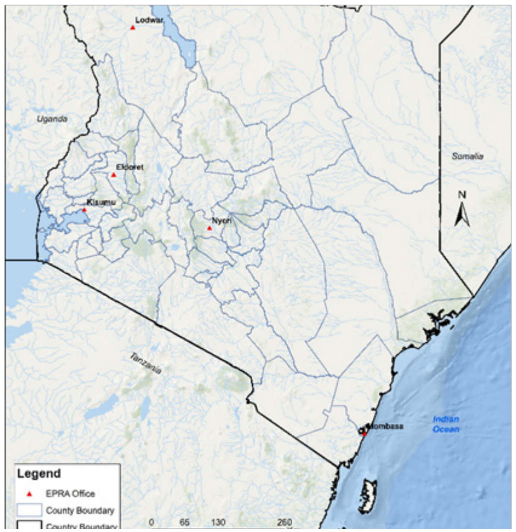


Company Demographics



Highlights of the Stakeholder Meeting

EPRA's role in the integration of VRE comprises of assigning commissioning dates (COD) to proposed projects and approving PPA's and generation licenses. Though the LCPDP process needs harmonisation, EPRA is involved in both its technical engineering analysis and economic analysis. Additionally, EPRA is the custodian of both the Kenya National Transmission Grid Code (2016) and the Kenya National Distribution Grid Code (2017). The grid code review committee will constitute of powerplant operators and representatives from the energy state agencies. Members may require training in both transmission and distribution grid code design.

4.4 Geothermal Development Company (GDC)

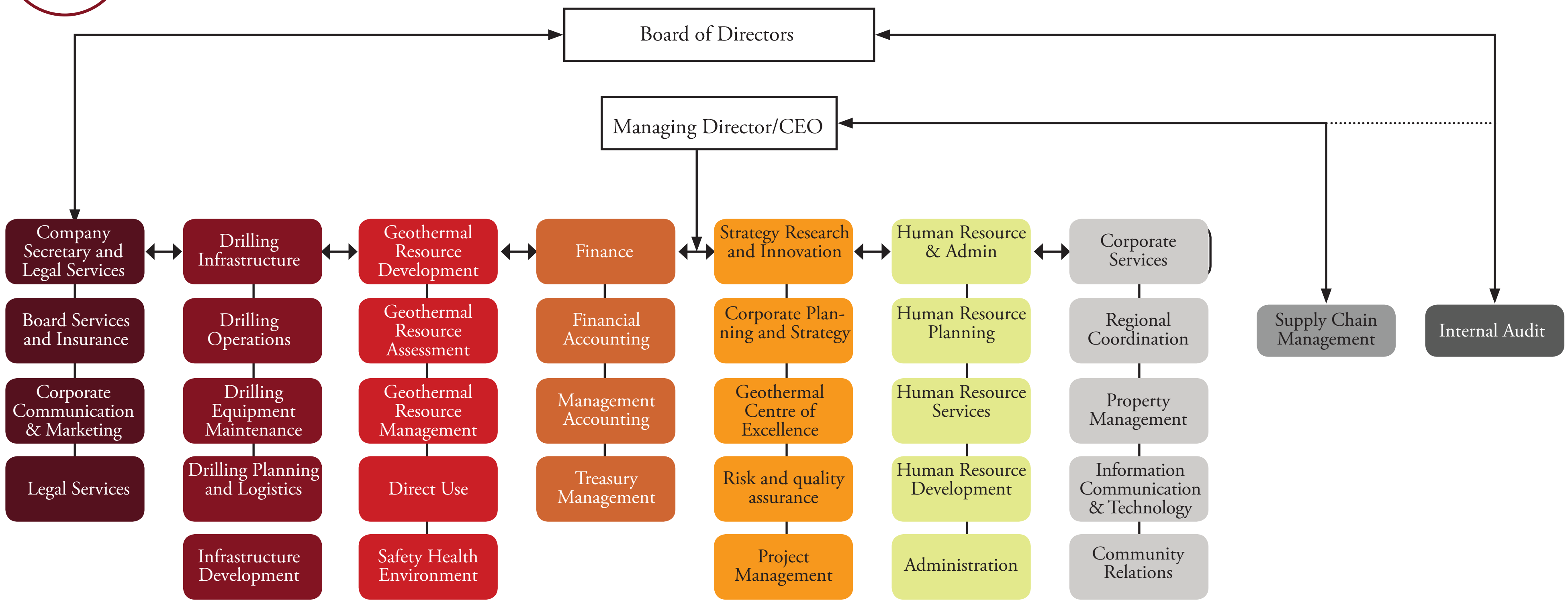
The Geothermal Development Company (GDC) is a fully government-owned company in Kenya's energy sector. Formed in 2008, its main goal was the optimization of the vast geothermal resource in the rift valley for electricity generation and other direct uses.

GDC fulfills its mandate through surface exploration and drilling for steam, availing steam to power plant operators for electricity generation and managing the geothermal reservoirs. It then sells the geothermal steam to KenGen and private investors for electricity generation. GDC is the government's tool for financing risks associated with geothermal exploration and drilling.

Geothermal Development Company

Green Energy for Kenya

Organisational Structure



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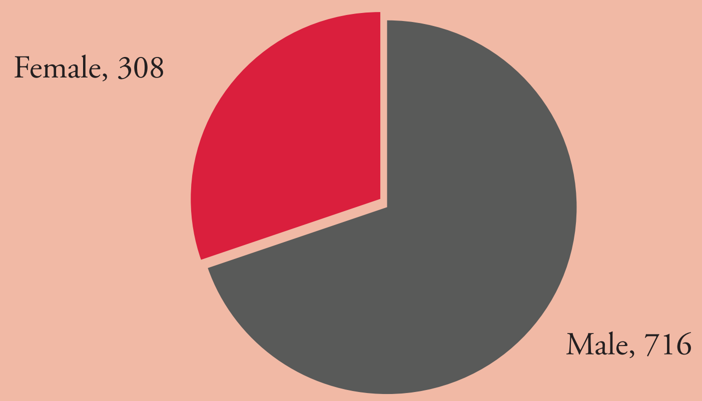

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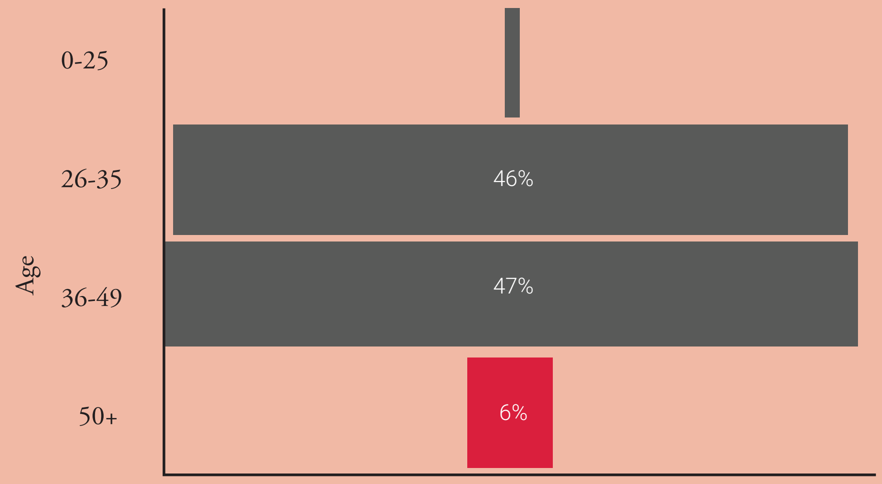

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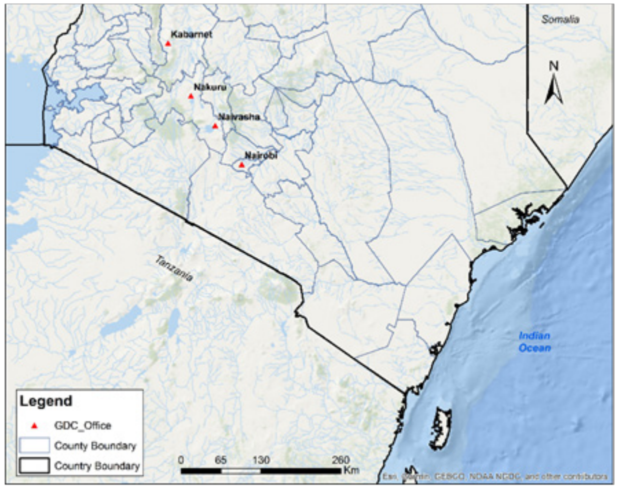


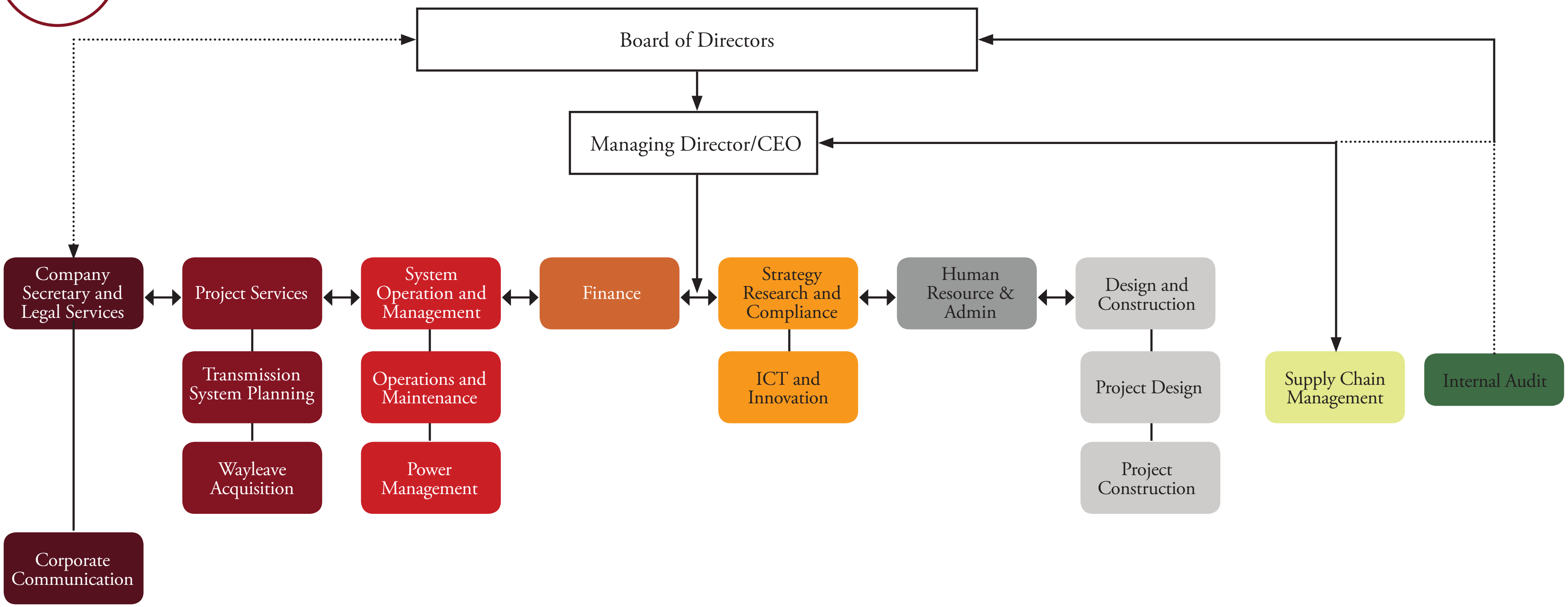
Highlights of the Stakeholder Meeting

GDC, though not involved in the development or management of VRE projects, is a key stakeholder in the power planning process through the LCPDP and VRE committees. As a suggested mitigating effort of VRE variability, battery storage and other storage systems should be incorporated into the LCPDP. Also, grid stability reports should be produced annually to gauge the need for power plants through the FiT process in the subsequent year.

4.5 Kenya Electricity Transmission Company Limited (KETRACO)

Kenya Electricity Transmission Company Limited (KETRACO) is a fully government-owned state company incorporated on 2nd December 2008. The Company was established to develop a new high-voltage electricity transmission infrastructure which forms the backbone of the national transmission grid. Its core business is to plan, design, build, and maintain electricity transmission lines and associated sub-stations. These transmission lines evacuate power from generating plants and inter-connect the Kenyan grid with the neighbouring countries' grids to facilitate regional power trade.

Organisational Structure



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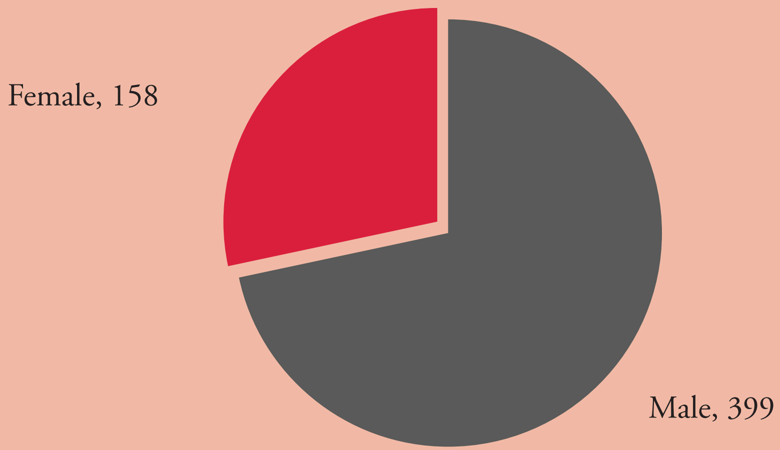

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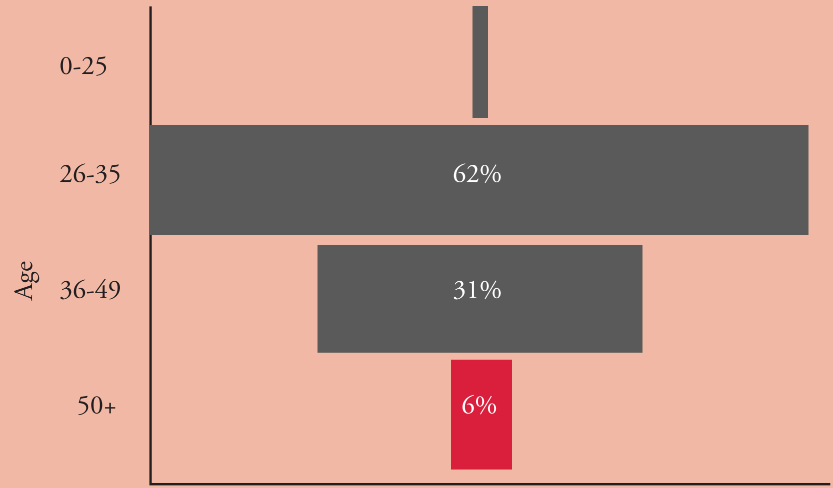

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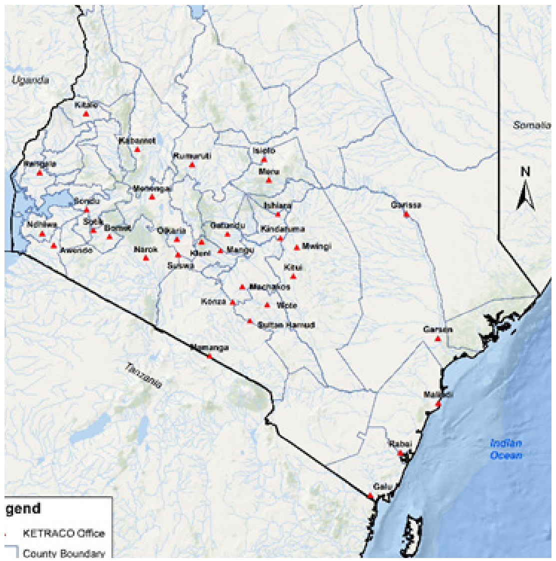
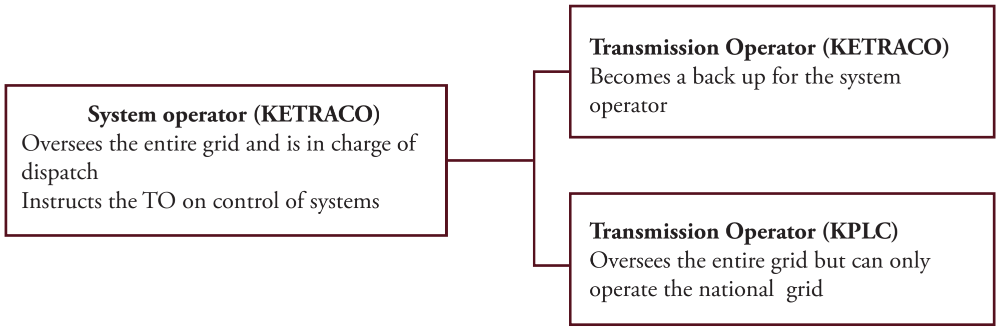


Highlights of the Stakeholder Meeting

Under the Energy Act 2019, a task force has been set up to advise on a new proposed arrangement for the national system operator. KETRACO proposes the following systems operation structure:

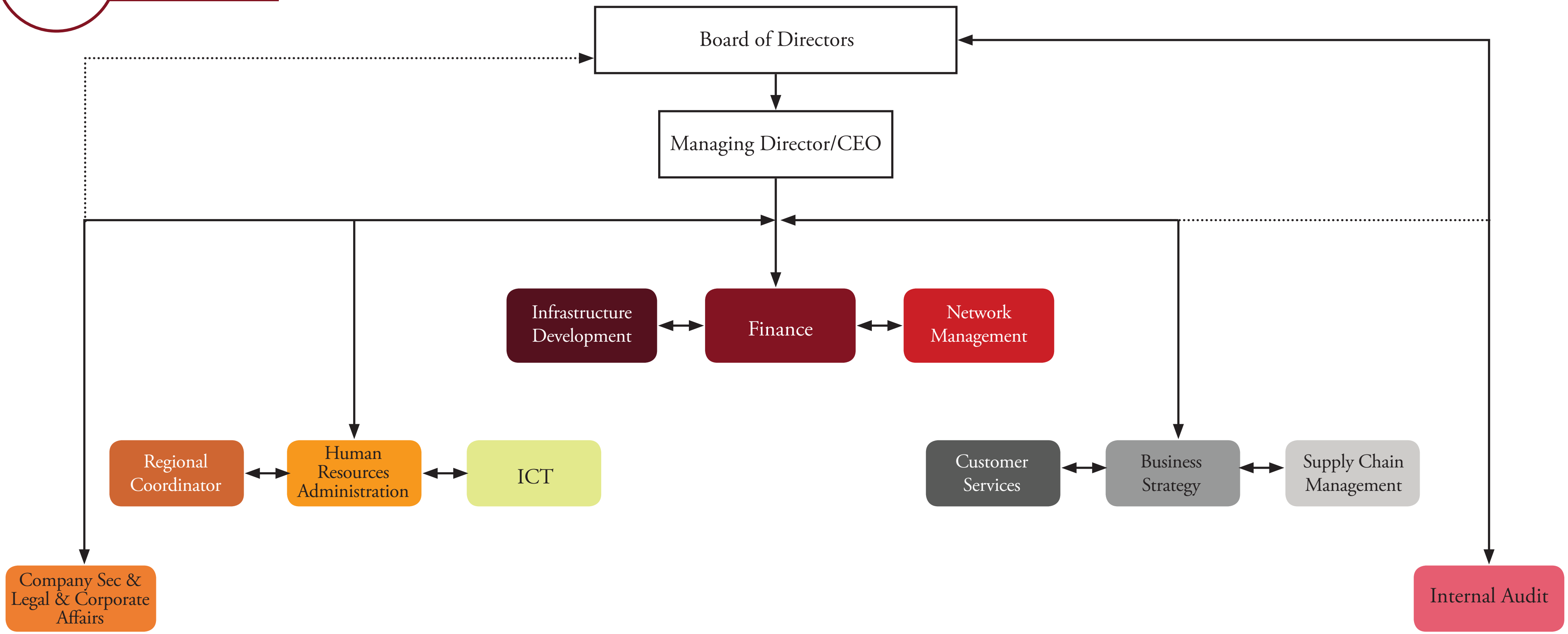
It is suggested that automatic generation take the position of the National Control Center. Additionally, benchmarking and trainings are required on system studies and on integration of VRE in the power system. There also exists a gap in data analysis and management in the institution that will aid in future system studies.



4.6 Kenya Power

Formed in 1922 as the East Africa Power and Lighting Company, it later rebranded to Kenya Power and Lighting Company in 1983 and then Kenya Power in 2011. The Company's initial key mandate is to plan for enough electricity generation and transmission capacity to meet demand; building and maintaining the power distribution, transmission network and retailing of electricity to its customers. The Government has a controlling stake at 50.1% of shareholding with private investors at 49.9%. Kenya Power is listed on the Nairobi Securities Exchange.

Organisational Structure



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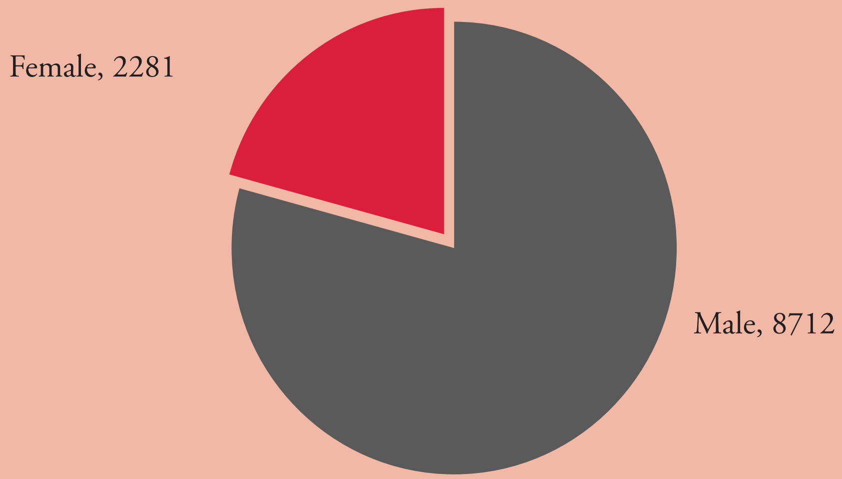

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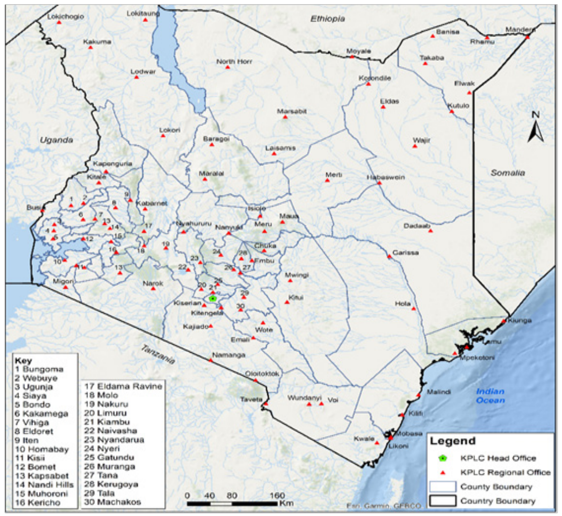


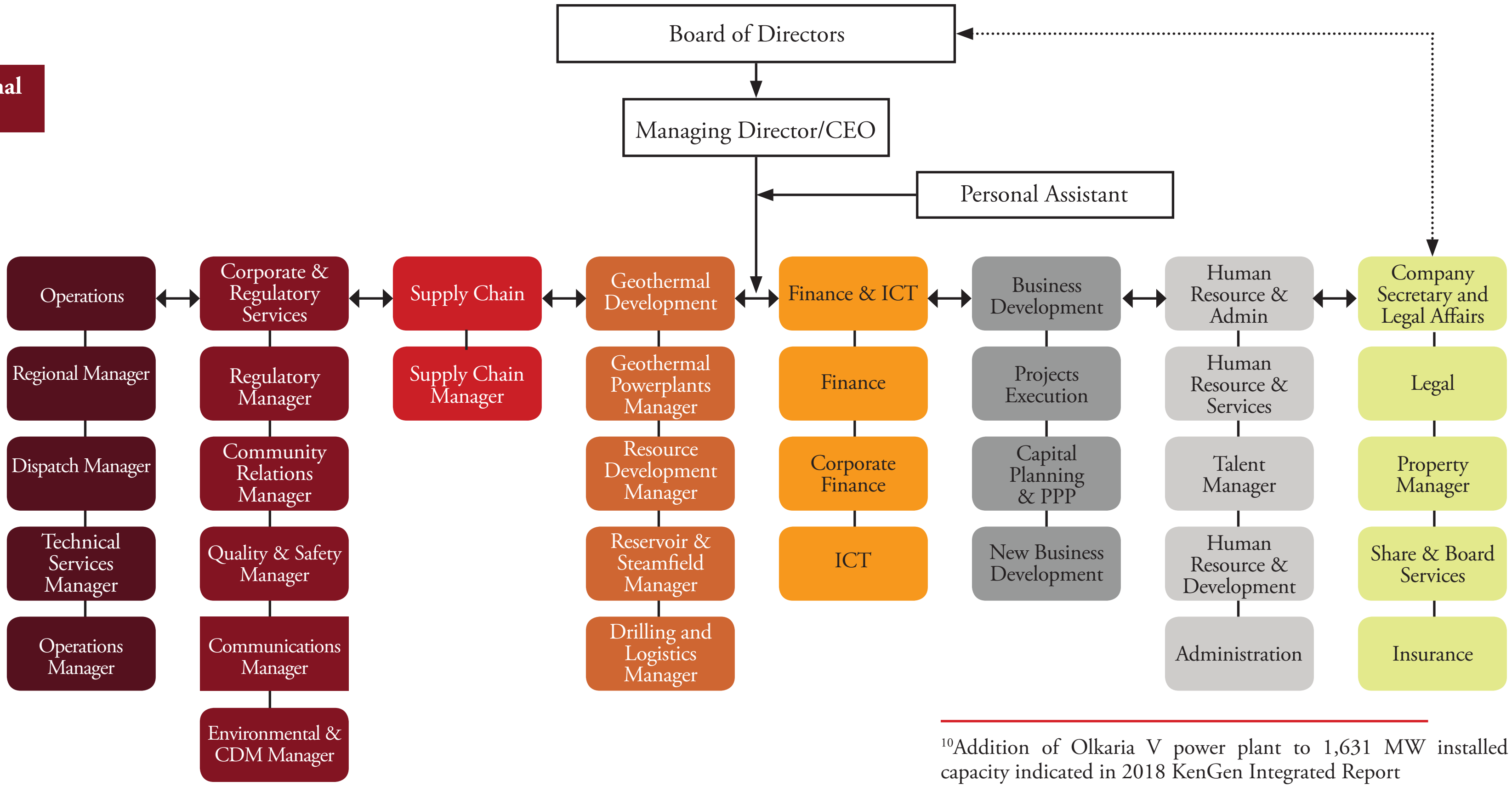
Highlights of the Stakeholder Meeting

Approximately 310 MW wind is currently run as a baseload or “must-run” energy source mostly due to the take or pay PPA. This model is a risk to the cost-effectiveness of merit orders because of being compelled to run it. Additionally, this accounts for a large percentage of installed capacity, which is variable and somewhat unpredictable. The spinning reserve is currently 15 MW and should ideally be equal to the largest VRE plant in the system. This indicates a spinning reserve shortfall of nearly 300 MW. The country’s total baseload has increased and is surpassing the current daily demand, which is projected at 1,400MW and peak demand at 1,800MW. This is mostly due to the requirements set that all hydros, geothermal, and VREs are a ‘must run’-The system is made to run politically rather than technically

4.7 KenGen

KenGen was founded in 1954 as the Kenya Power Company and was managed by the East Africa Power & Lighting Company (EAP&L), which later became the Kenya Power and Lighting Company. Following the restructuring of the energy sector in 1997, Kenya Power Company separated from Kenya Power and rebranded to KenGen. It is mandated to develop, manage and operate electricity generation powerplants. The Government has a controlling stake at 70% of shareholding, with the remaining 30% floated on the Nairobi Securities Exchange (NSE). KenGen is the largest power producer in Kenya with hydro, geothermal, wind and thermal power plants across the country, with an installed capacity of over 1,805 MW[10].

Organisational Structure



[10]Addition of Olkaria V power plant to 1,631 MW installed capacity indicated in 2018 KenGen Integrated Report

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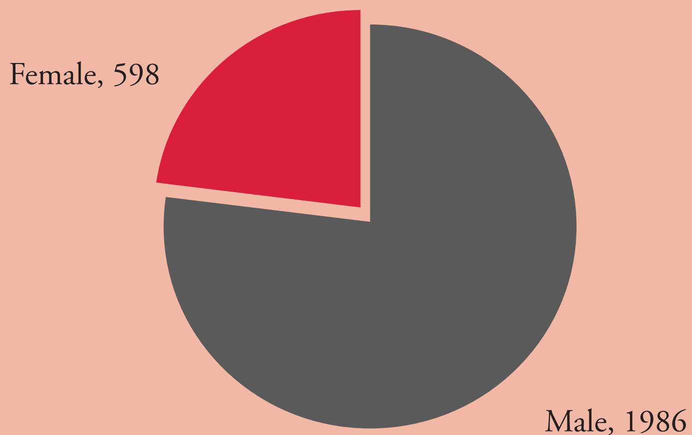

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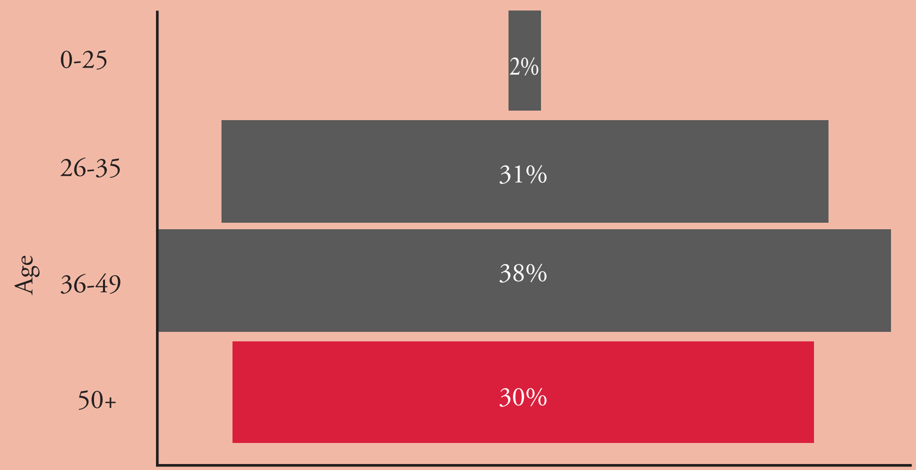

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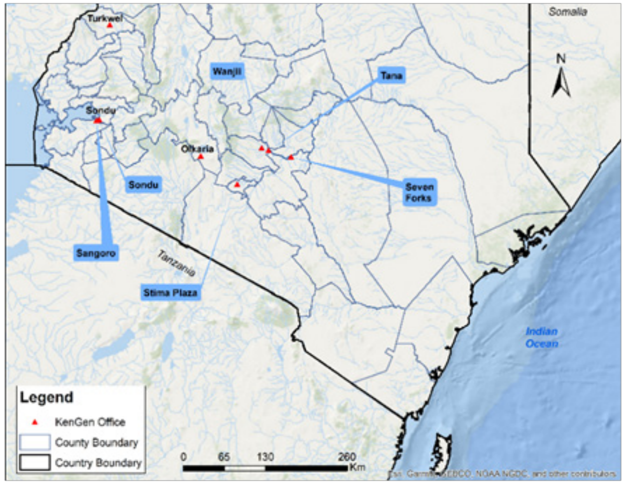


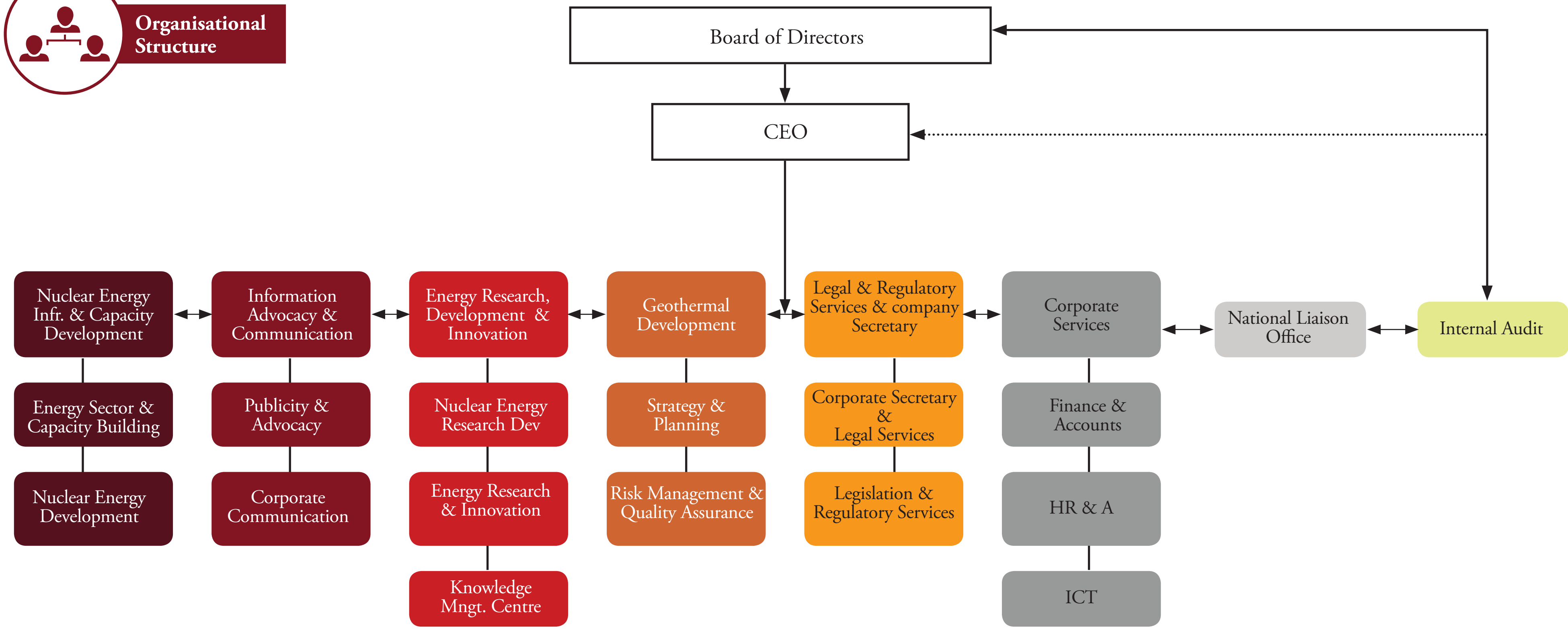
Highlights of the Stakeholder Meeting

KenGen is a key VRE developer in the country. Currently operating the Ngong Hills wind power plant, the organisation plans on further development of wind power in other regions. Additionally, the organisation's planning department takes part in the LCPDP process. Although the Ngong wind plant currently does not have forecasting, KPLC has historical data on wind speeds since its inception, which forms the basis of current forecasting.

4.8 Nuclear Power and Energy Agency (NuPEA)

The Kenya Nuclear Electricity Board (KNEB), now the Nuclear Power and Energy Agency (NuPEA), was formed as a statutory body on 16th November 2012 from the Nuclear Electricity Project Committee. NuPEA is mandated to promote and develop the Kenya Nuclear Power Programme. Under the Energy Act (2019) the mandate includes research, development, innovation on energy technologies and capacity building of the energy sector.

Organisational Structure



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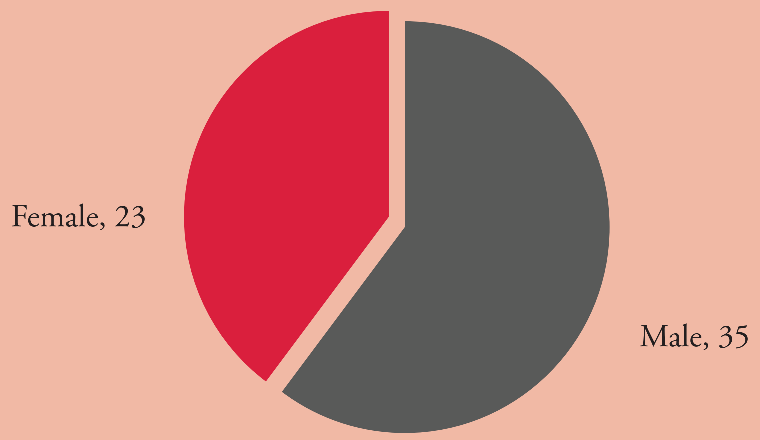

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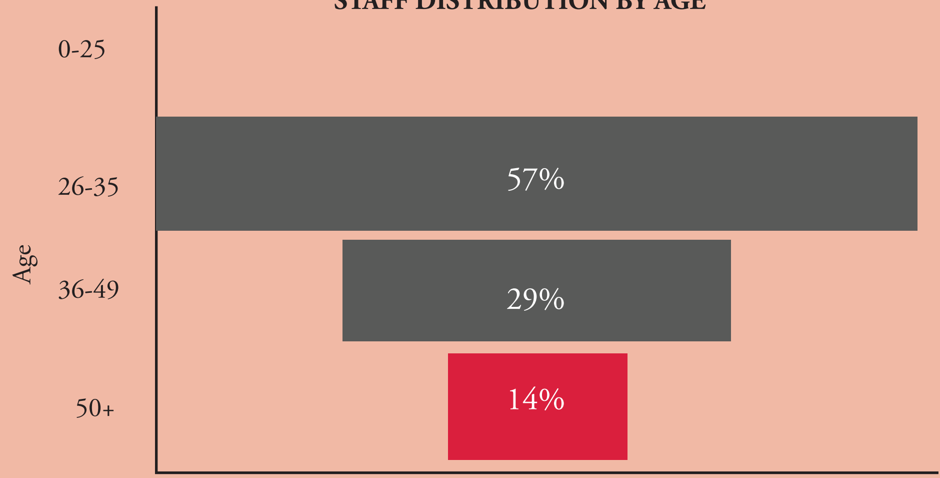

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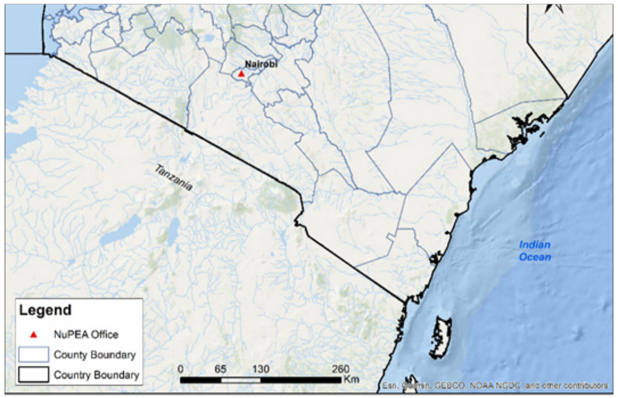


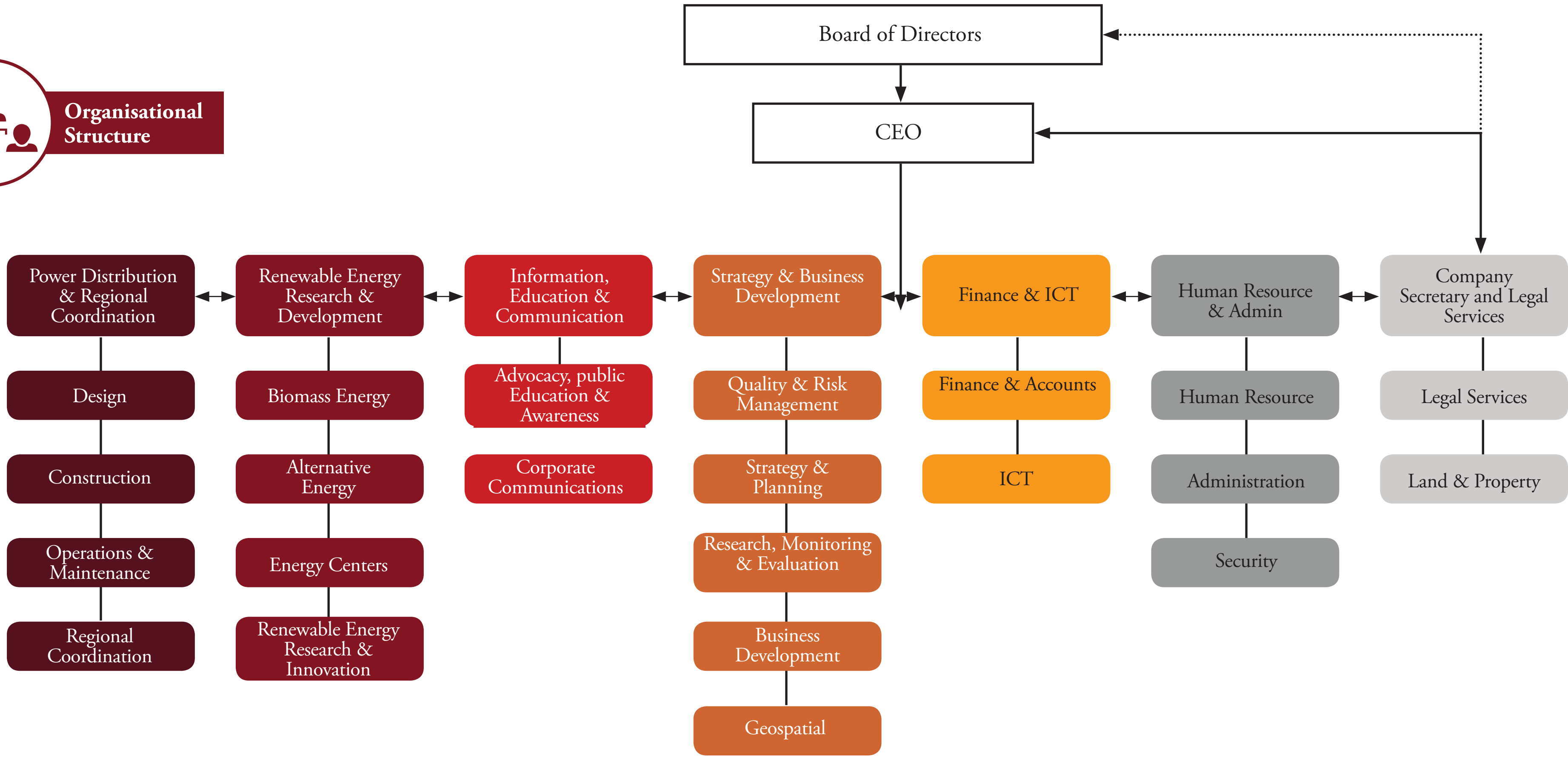
Highlights of the Stakeholder Meeting

In accordance with the Energy Act 2019, NuPEA is in the process of developing a new organizational structure. Currently, a new directorate has been created to coordinate all aspects of research and development including VRE technologies. The directorate is composed of 2 staff members against the required 22 for proper function. Additionally, the capacity development department mandated with developing capacities in the energy sector has 6 employees, with 2 dealing with renewable energy instead of 25 employees at full capacity. The organisation is also represented in the LCPDP process.

4.9 Rural Electrification and Renewable Energy Corporation (REREC)

The Rural Electrification Authority (REA), now The Rural Electrification and Renewable Energy Corporation (REREC) was established in 2006 with the primary mandate of accelerating the rate of rural electrification in Kenya, previously coordinated by the Ministry of Energy. With the enactment of the Energy Act 2019, REREC's directive has been expanded to include the development and promotion of renewable energy such as wind, solar, biomass, small hydro and municipal waste. REREC developed and currently operates a 50 MW grid-tied solar plant in Garissa.

Organisational Structure



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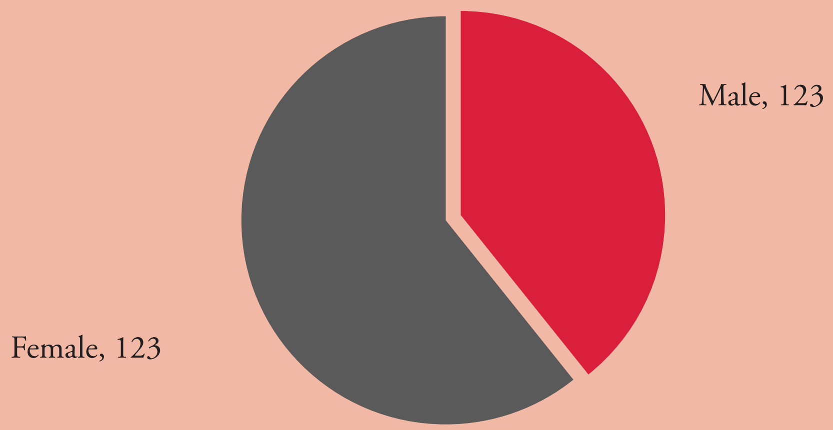

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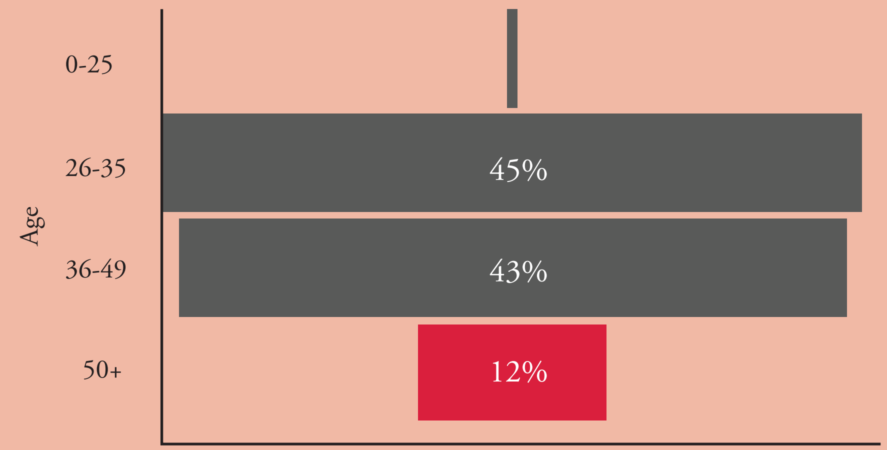

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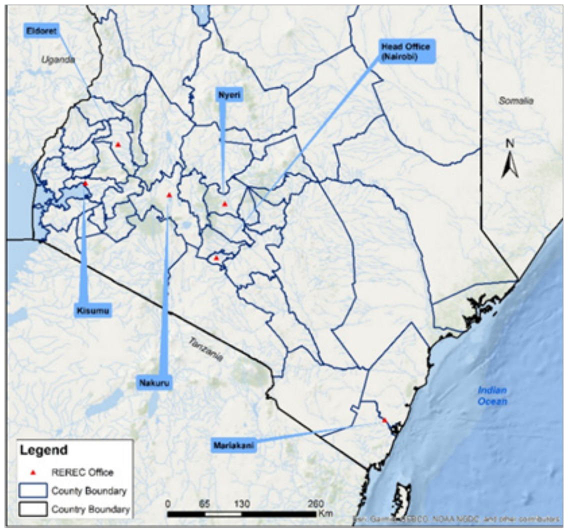


Highlights of the Stakeholder Meeting

With the mandate of promoting renewable energy including VRE, REREC developed the Garissa solar PV 50 MW plant and is currently carrying out a feasibility study of 100 MW solar/wind hybrid in Muhoroni. Presently, the Garissa plant has basic weather instruments and does not receive any forecasts from the Kenya Meteorological Department. The plant is operated by KenGen staff with experience in handling VRE and the EPRA licensing requirement for management. The plant is maintained by the EPC[11] contractor whose term comes to an end in November 2020. There has been no deliberate training by the contractor to personnel including cleaning the systems. Additionally, no training has been done by KenGen to REREC staff on plant operations.

[11]Engineering, Procurement and Construction

4.10 Institutions Outside The Energy Sector

4.10.1 Kenya Meteorological Department – Meeting Highlights

The Kenya Meteorological department currently interacts with KenGen as clients for flooding forecasts and rainfall for hydro plants. This includes run-off calculations. This is done during the seasonal, monthly and weekly predictions at the catchment areas. Additionally, the Met department generated long term wind projections for the Lake Turkana Wind Project during the project inception. There is currently no routine forecasting service offered for VRE power plants. Out of the 10 employees engaged in forecasts, only 2 staff members are experts in modelling & numerical weather prediction with current models used for wind forecasts, and none for offering solar forecasts predictions.

4.10.2 Voltalia – Meeting Highlights

Voltalia has experienced delays in project development with obtaining the generation license and commissioning date taking approximately two years. A major challenge faced by the developer during project development is the unpredictability in the development process between the Ministry of Energy, EPRA and the treasury. This is seen by inconsistency in policy as the policy document has changed between initial project development to date.

4.10.3 Strathmore Energy Research Centre (SERC) – Meeting Highlights

The SERC currently offers certificate training courses in T1/T2, T3 hybrid and T3 grid-tied solar projects. The curriculum is derived from the National Industrial Training Authority (NITA) and is offered to persons with an engineering background. A new curriculum is under development as part of the new solar PV regulations. The trainings are designed for project developers and not national power system operators.

4.10.4 World Bank – Meeting Highlights

The World Bank supports VRE deployment through technical assistance and funding, which is directed mostly at the government through the Ministry of Energy. It has assisted in the development of the renewable energy auction framework. Additionally, the bank offers transaction advisory services and financing for grid integration studies. The Bank seeks to support a supply-demand balance study and solar deployment strategy in 2020. The possibility of oversupply is concerning, and more emphasis should be given to geothermal energy, which is not variable.

4.10.5 KfW – Meeting Highlights

KfW does not have any investments in VRE though DEG does and is currently interested in 42 MW of solar projects that are not yet committed. KfW interacts with the Ministry of Energy and other state energy agencies primarily through financing of projects and to a small degree technical assistance. The level of VRE requires strengthening of the transmission and distribution infrastructure. VRE development should be optimised with energy storage technologies and grid backbone development. Additionally, the technical capacity of the system operator should be enhanced.

4.10.6 Sowitec – Meeting Highlights

Sowitec is currently in the process of securing EOI approval; however, they have obtained a letter of No Refusal. The FiT pipeline should be re-examined since the issuance of EOI's has been suspended since 2016 and some projects have not been developed in light of the actual electricity demand growth in the country. Sowitec observes that the PPA process should be clearer to project developers as it is currently a moving target. Additionally, the government should commercialize and prioritize VRE plants offering auxiliary services such as voltage support and reactive power supply.

5 Human Resource Capacity Gaps

5.1 Individual Level Assessment

An online, anonymous self-assessment sheet was sent to specific staff identified during the key stakeholder meetings whose roles are directly related to the origination, planning and operation of VRE within the state agencies. The number of responses registered, from the different agencies, is 31, as indicated in Figure 15. The source of the response per agency is as follows: MoE – 5, GDC – 3, Kenya Power – 8, KETRACO – 7, NuPEA – 3, EPRA – 1, KenGen – 3 and REREC – 1. Figure 15 gives more insights into the male-female ratio and the age of the respondents.

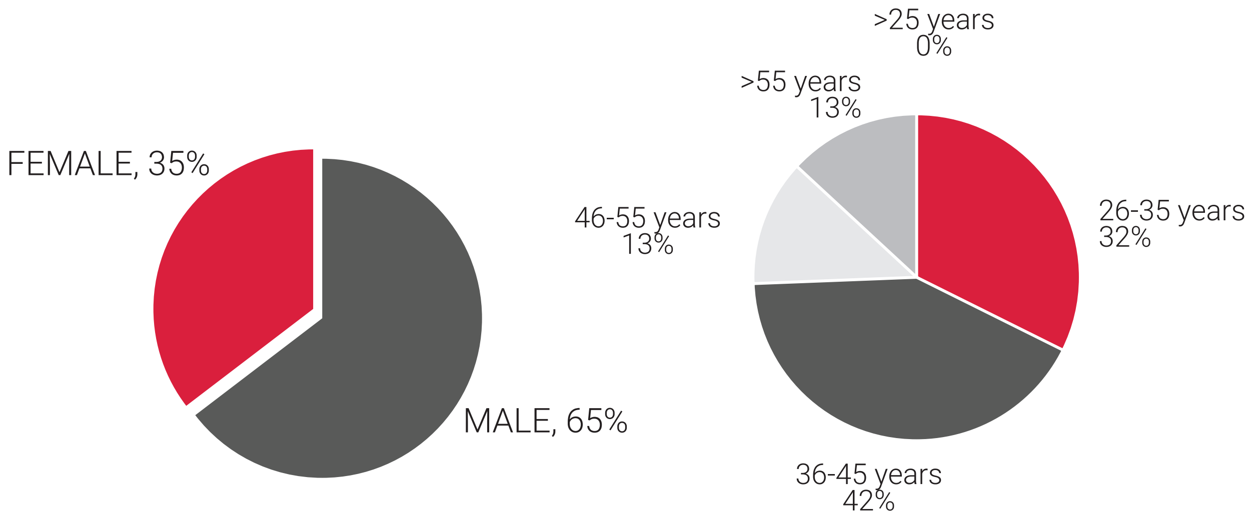


Figure 15: Summary of Test Respondents

68% of respondents indicated they have a postgraduate degree, which implies that the staff in-charge of VRE across the sector are highly qualified academically. All respondents indicated they required additional training to enhance their roles in managing VRE.42% of the respondents indicated that their workload is currently unmanageable and listed technical barriers rather than human capacity gaps as possible solutions to this.

As mentioned earlier in this assessment, the ability to effectively deploy human resources is limited by their access to required facilities, tools and equipment. Training in operating AGC systems, for example, without having functional AGC systems, will not improve the current state of VRE operations. Human development capacity in many instances will have to be supported by investments in the tools needed. In relative terms, VRE at 15% should be manageable but the structuring of the contracts which require the treatment of VRE as baseload supply on the merit order and the largely manual generation control systems complicates the situation making it difficult to have smooth operations.

The assessment also asked some perception questions on the state of VRE to 15 respondents with knowledge of the sector. This was to gauge their attitude towards

the current and projected state of future VRE. In both questions, close to half of the respondents gave a rating of 2/5 on the country's preparedness to deal with VRE.

Table 4: Perception of Readiness to Manage VRE Resources

#	Perception Question	1	2	3	4	5
1	On a scale of 1-5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the current contribution (15%) of VRE?	13%	47%	33%	7%	0%
2	On a scale of 1-5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the current contribution (23%) of VRE?	20%	53%	13%	13%	0%

5.2 Organizational Level Assessment

The capacity gaps were identified from i) the meetings held with the energy sector stakeholders, ii) best practice case studies and iii) the online self-assessment test responses by staff members working specifically in VRE related roles. It was found that none of the organizations have a department that is designated for VRE operations. A red-amber-green (RAG) rating system was used with 3 (red) indicating a major need and 1 (green) a minor need as shown in the tables below. Final averages of the rows display the degree of criticalness across the roles while averages of the columns display the human capacity per institution. Roles that need strengthening under origination include: mainstreaming VRE into long-term energy planning, implementation, monitoring and evaluation of VRE. Under integration, financial and economic analysis of VRE plants and simulations of impact of VRE (load flow analysis, capacity value forecasting errors etc) require significant support. Lastly, under operation most of the roles require strengthening apart from dispatch and scheduling and contingency analysis, which scored 2/3.

To be noticed, scores tabulated across the columns with values greater than 2.5 indicate that the activity needs critical capacity development.

Origination

Covering the planning and review of VRE projects, the human capacity gaps identified at the origination level across the different stakeholders were those that had values higher than 2.5 in the column indicated scoring, as seen in Table 5.

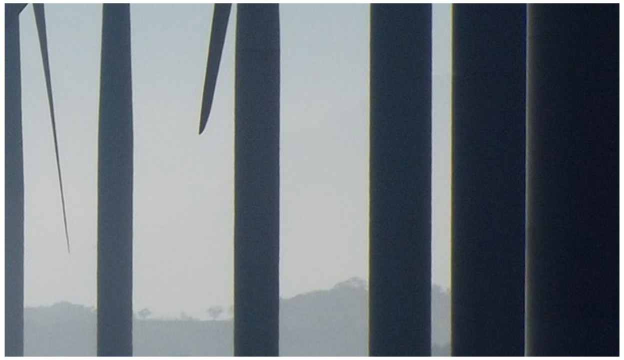


Table 5: Origination Capacity Gaps

RATING: Red = 3, Amber = 2, Green = 1 and White = 0

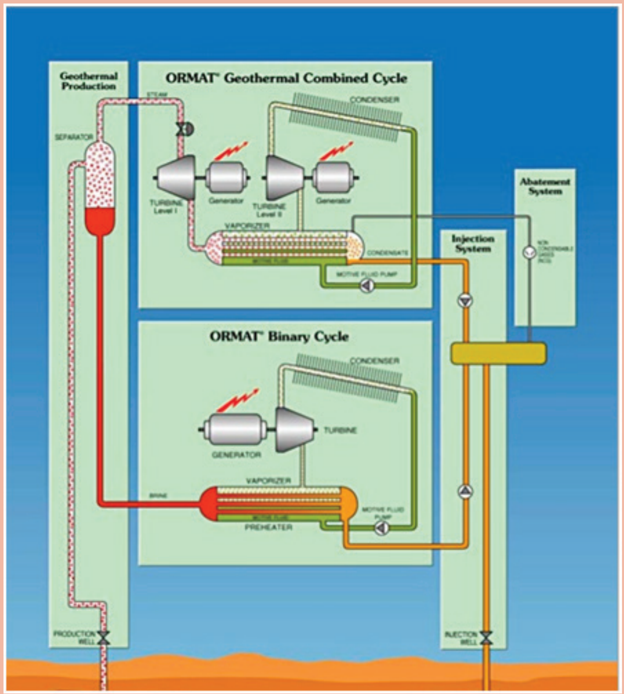
1 – MoE, 2 – EPRA, 3 – GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 – Kenya Met Dept., 10 – Executive/Legislature

	ORIGINATION - KEY ROLES	1	2	3	4	5	6	7	8	9	10	SCORE
1	Policy and regulation formulation											1.0
2	Energy planning and modelling											1.0
3	Mainstreaming VRE into long-term energy planning & modelling											3.0
4	Implementation, monitoring and evaluation											3.0
5	Technical and financial review of proposals (EoI and proposal)											2.0
6	Renewable energy resource analysis											2.0
7	Transmission and distribution planning											2.0
8	Training and sectoral capacity development											3.0
9	Research and development											2.8
	TOTAL	**17.0**	**13.0**	**10.0**	**14.0**	**13.0**	**11.0**	**12.0**	**16.0**	**0.0**	**4.0**	
	TOTAL/ ROLE	**2.1**	**2.2**	**2.0**	**2.0**	**1.9**	**1.8**	**2.0**	**2.3**	**0.0**	**2.0**	

From the overall rating represented in the last row, MoE (2.1), GDC (2.0), KenGen (2.0), Executive/ Legislature (2.0), EPRA (2.2), KETRACO (2.0) and NuPEA (2.3) require critical capacity development to execute their roles efficiently. As indicated in Table 5, key roles requiring critical capacity development include:

- The mainstreaming of VRE in long-term planning and modelling - This involves modelling and analysing the technical readiness of the entire power system to proposed VRE power plants during the LCPDP process to correctly gauge the recommended level of VRE to be installed in the country.
- Implementation, Monitoring and Evaluation – This entails the continuous evaluation of the project pipeline outlined in the LCPDP in light of current country prevailing conditions. It involves analysing projected economic growth and implementation of country flagship projects to align the projected power demand to be fulfilled by proposed power plants.
- Training and sectoral capacity development – This is primarily for NuPEA, which gains the mandate of energy sector capacity development under the Energy Act 2019. In this regard, NuPEA requires a mix of upskilling in Variable Renewable Energy management and hiring new expertise in the field to fulfill its mandate.
- Research and development – Similar to the training mandate, NuPEA is also tasked to lead sectoral research and development. This capacity is currently lacking and is therefore required. To gain this expertise it is recommended that NuPEA collaborates with a university to set up an innovation lab in addition to hiring an energy research team including a VRE expert.

Case Study III – Ormat: Dispatchable Geothermal Plant (VRE Tracking)



Puna Geothermal Venture (PGV), a subsidiary of Ormat International, and Hawaii Electric Light Company (HELCO) reached an agreement to expand the existing 30 MW geothermal plant operated by PGV by 8 MW to become the fully dispatchable geothermal plant[12].

The PGV plant was first commissioned in 1993 in the lower Kilauea East Rift Zone on the southeast side of the Big Island. The plant comprises of ten Ormat Geothermal Combined Cycle Units (GCCU) that incorporate a back-pressure steam turbine and Organic Rankine Cycle in a modular unit. In the expansion project, in order to take advantage of the unused energy in the condensate from the current GCCUs, two Ormat Energy Converter (OEC) bottoming units (binary cycle) were added to optimize energy recovery. The inclusion of the two OECs converted the PGV facility into an Integrated Geothermal Combined Cycle (IGCC) technology (indicated in adjacent figure).

To be fully dispatchable and for the plant to be involved in the HELCO automated generation control (AGC), the plant required to have a mechanism for bypassing the geothermal fluid around some of the turbines, therefore, power generation is controlled between the ten GCCU's and the two OEC bottoming units. The plant has a power generation range of between 22 MW and 38 MW, a ramp rate of 2 MW/min and a spinning reserve of at least 3 MW. The plants SCADA system is integrated with HELCO's AGC enabling the system control to have data access on available capacity and spinning reserve. The plant SCADA system receives required power requests from the AGC and responds accordingly in line with operational limits.

As demonstrated in the PGV plant, multi-fluid geothermal power plants can provide dispatchable power which is especially important for power systems with a high percentage of VRE installed capacity. However, extensive analysis of the geothermal reservoir and assessment of control systems should be carried out to ensure the design meets required ancillary service requirements.

[12]Nordquist J., et al (2013), Automatic Generation Control and Ancillary Services, GRC Transactions, Vol. 37

Integration

At the integration level, the human capacity gaps identified across the different stakeholders were those that had values higher than 2.5 in the column indicated scoring, as seen in Table 6.

Table 6: Integration Capacity Gaps

RATING: Red = 3, Amber = 2, Green = 1 and White = 0

1 – MoE, 2 – EPRA, 3 GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 - Kenya Met Dept., 10 – Executive/Legislature

	INTEGRATION - KEY ROLES	1	2	3	4	5	6	7	8	9	10	SCORE
1	VRE Resource forecasting											3.0
2	Financial and economic analysis of plants											2.0
3	Technical analysis of VRE plants											2.3
4	Transmission system scenario analysis											2.0
5	Ancillary services requirements analysis											1.0
6	Simulations (Load flows analysis, capacity value forecast errors, etc)											3.0
7	Grid Integration studies											2.3
	TOTAL	0	11	0	11	10	3	0	10	0	0	
	TOTAL/ ROLE	0	2.75	0	2.2	2	3	0	2	0	0	

From the overall rating represented in the last row, EPRA (2.75), KENGEN (2.2), REREC (3.0), Kenya Power (2.0 and NuPEA (2.0), require critical capacity development to efficiently execute their roles at the integration level. It should be noted that a score of 0 means that the agency/stakeholder at hand does not fulfill that mandate or role.

The following are the human capacity gaps at the integration level:

- The current process is structured such that prospective power plant developers conduct the grid integration studies of the proposed plant. This was found to be unique as other countries have the system operator or off-taker to conduct the study, ensuring the study is done independently of the power plant developers' interest, therefore being more objective. In this regard, this capacity is urgently lacking in Kenya Power.
- Financial and economic analysis of VRE plants – This involves enhancing the capacity to undertake detailed financial assessments of proposed business models as outlined in VRE power plant feasibility studies. This will ensure a good understanding of the implications of take-or-pay clauses in PPA discussions.
- Power system simulations – This involves modelling the technical impact a proposed VRE power plant has on the greater system. It includes load flow analysis, power system modelling, and capacity value forecast errors among others.

Operations

At the operation level, the human capacity gaps identified across the different stakeholders were those that had values higher than 2.5 in the column indicated scoring as seen in Table 7

Table 7: Operations Capacity Gaps

RATING: Red = 3, Amber = 2, Green = 1 and White = 0

1 – MoE, 2 – EPRA, 3 GDC, 4 – KenGen, 5 – Kenya Power, 6 – REREC, 7 – KETRACO, 8 – NuPEA, 9 - Kenya Met Dept., 10 – Executive/Legislature

	OPERATIONS - KEY ROLES	1	2	3	4	5	6	7	8	9	10	SCORE
1	Advanced forecasting (weather)											3.0
2	Advanced forecasting (plant power)											3.0
3	Sub-hourly dispatch and intra-hourly scheduling											2.0
4	Contingency analysis, congestion management and economic dispatching											2.0
5	Storage and AGC operations											2.7
6	Operations and maintenance of VRE plants (e.g. Garissa Solar)											2.5
7	Impact of VRE plants on the existing firm capacity plants											3.0
		0	0	0	14	6	12	0	0	3	0	
	TOTAL/ ROLE	0	0	0	2.8	2	3	0	0	3	0	

From the overall rating represented in the last row, REREC (3), KENGEN (2.8), Kenya Met Dept (3.0) and Kenya Power (2.0) require critical capacity development to efficiently execute their roles at the integration level. It should be noted that a score of 0 means that the agency/stakeholder at hand does not fulfill that mandate or role.

At the operation level the following were found to be the capacity gaps:

- Currently, there exists an urgent capacity gap in the operations and maintenance of the REREC Garissa Solar PV 50 MW plant. The plant is currently operated by KenGen colleagues and maintained by a Chinese contractor.
- No VRE specific weather forecasting is being offered by the Kenya Meteorological Department. Independent power producers currently fill this gap by purchasing weather data from international vendors. It is understood that a national weather forecasting facility will be established, it is therefore advised that structuring and training shall be conducted for this in close collaboration with Kenya Meteorological Department.
- Power plants are currently required to provide production forecasts 24 hours before operation. Best practice dictates that forecasts be as close to the time of operation as possible such as in Denmark which operates forecasts up to 5 minutes[13] ahead of operation. Though this requires advanced software and technical linkages between power producers' systems and the system control centre, training or exchange programmes should be carried out in tandem with sourcing the equipment.

5.3 System-wide Assessment

Kenya's energy sector is broadly divided into three streams: electricity, petroleum and other sub-sectors (including the cooking one). The electricity sub-sector is constituted of seven government agencies and a group of private sector interests, as shown in Figure 16. There are several interagency coordinating and consulting committees including the Feed-in Tariff Committee, the LCPDP Committee, GIS Committee, Variable Renewable Energy Committee, Power Demand Committee among others. The FiT and LCPDP committees have the greatest bearing on VRE project origination while the recently constituted VRE committee cuts across the three stages – origination, integration and operations.

[13]J. Cochran et al (2012), Integrating Variable Renewable Energy in Electric Power Markets: Best Practice from International Experience, NREL

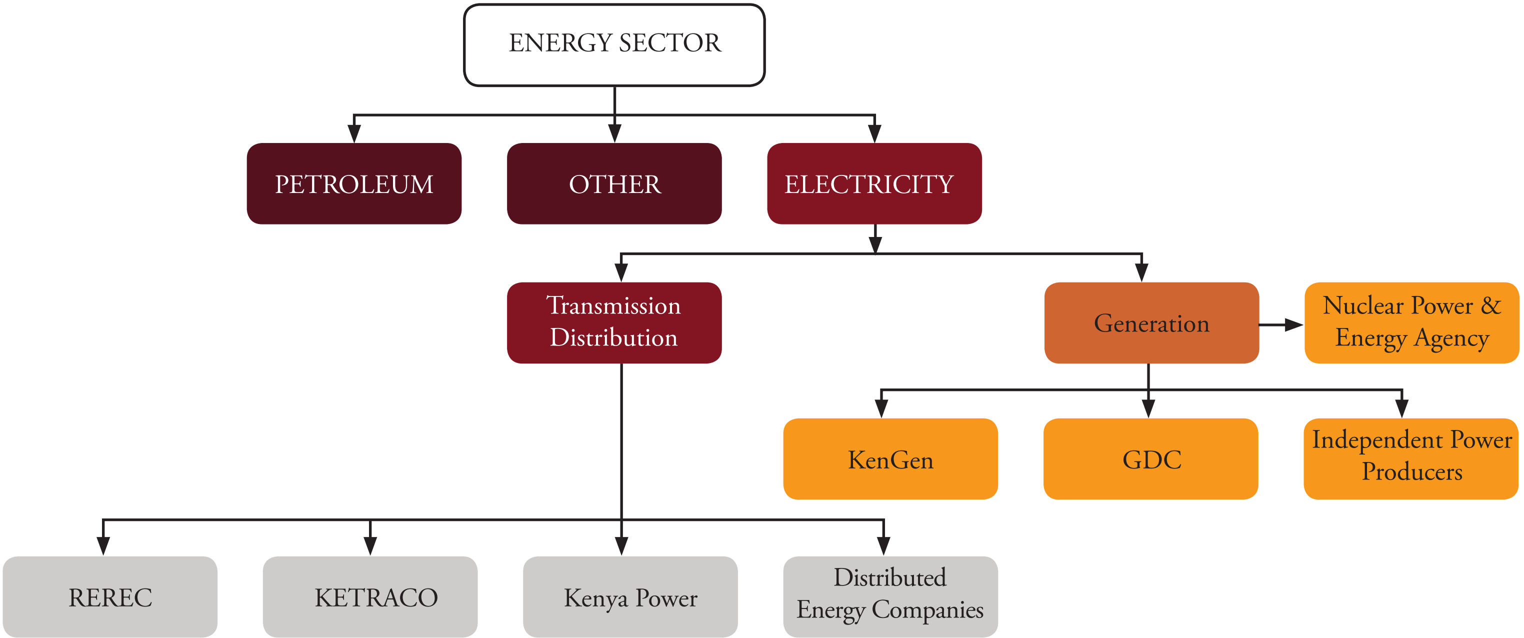


Figure 16: Energy Sector Stakeholders

Until recently, the FiT and the LCPDP process worked independently of each other, although the outputs of the two overlap significantly. Also, the political drive to deliver the Vision 2030 flagship projects influenced the intake of independent power producers. In 2013, these projects included iron and steel smelting industries under special economic zones, standard gauge railway, ICT parks, LAPSSET, which would require an additional generation capacity of 2,000 MW, 1,171 MW, 675 MW and 350 MW respectively. This anticipated demand led to a liberal policy of accepting as many viable proposals as could be received. Five years later, the demand for electricity has not kept up with supply and most of the projects have not been completed. Although there are areas for improvement, this assessment finds that there is general coordination within and across the agencies under the Ministry of Energy. Delivery of the anchor projects such as Konza Techno City, electric Standard Gauge Rail, steel mill, special economic zones, among others, which would have stimulated demand falls outside these institutions. A clear weakness in the process is effective communication between the policy implementers on one side, the policymakers and executive on the other side, or the failure of the policymakers and executive to follow the laid-out plans by the policy implementers, or both. This assessment did not interview policymakers or the executive, so the view discussed here are from the policy implementers.

The main recommendation that emerged is the need for a centralized data-driven coordinating process for onboarding all power producers – independent and

public. This process should be closely driven by realistic demand forecasting. Secondly, the policy implementers should be better equipped to effectively communicate potential results and consequences of political decisions that do not align with the formal energy planning processes, including the LCPDP. This may entail conference/workshops that outlines the basic workings of VRE systems, their benefits and drawbacks. The target of such a conference would be politicians and policymakers with a limited engineering background. Additionally, exposure trips to the countries that have best practice VRE integration is advised. This will provide hands-on experience to the decision-makers.

ANNEXES

ANNEX 1: LIST OF MEETINGS AND ATTENDEES

MoE – Target Setting meeting – 19/09/19

#	Name	Organization	Role/Position
1	Betty Akoth	GIZ	Project Advisor
2	Murefu Barasa	EED	Mg. Partner
3	Clara Wanjiru	EED	Senior Associate
4	Beryl Ajwang'	EED	Senior Manager
5	Eng. Isaac Kiva	MoE	SRE
6	Jonathan Mbutu	REREC	VRE
7	Chrispin O. Lupe	MoE	Chief Geologist
8	Naomi Githui	MoE	PSC
9	Johnson Njeru	KenGen	VRE
10	Jackson Mutonga	GIZ	Advisor
11	Odedeh Henry	KETRACO	Snr. Mgr. Power
12	Martin Kitetu	EED	Senior Associate
13	Erick Ngala	PAC	Mg. Partner
14	Tom Maruti	MoE	Economist
15	Mungai Kihara	MoE	Engineer
16	Amos Nabaala	KPLC	Planning Eng.
17	Jones Magige	MoE	Engineer
18	Budgeree Lang'at	KETRACO	Engineer P&PD
19	Leonard Yegon	EPRA	Sn. Pw Analyst
20	Jonathan Ronoh	EPRA	Pr Elec. Officer
21	Eratus Kiruja	KPLC	Mgr Pw Systems
22	Charles Maloba	KPLC	Mgr System Ops

KenGen – 03/10/19

#	Name	Organization	Role/Position
1	Betty Akoth	GIZ	Project Advisor
2	Joel Ngugi	KenGen	Operations Manager
3	Ginalius Njiraini	KenGen	Asst Mgr Dispatch
4	Florah Kamanja	KenGen	Capital Planning Engineer
5	Johnson Njeru	KenGen	Ass Manager Capital Planning
6	Julie Mwaluma	KenGen	Chief HRD – L&D

NuPEA – 03/10/19

#	Name	Organization	Role/Position
1	Betty Akoth Onyando	GIZ	Project Advisor
2	Murefu Barasa	EED	Managing Partner
3	Edwin K. Chesire	NuPEA	
4	Hilda Mpakany	NuPEA	
5	Benedict Njuguna	NuPEA	
6	Clara Wanjiru	EED	
7	Beryl Ajwang’	EED	
8	Winfred Ndubai	NuPEA	

KETRACO – 04/08/10

#	Name	Organization	Role/Position
1	Betty Akoth Onyando	GIZ	Project Advisor
2	Murefu Barasa	EED	Mg. Partner
3	Nathan Sirai	KETRACO	Senior Officer L&D
4	Budgeree Lang'at	KETRACO	Engineer P&PD
5	Henry Odedeh	KETRACO	Senior Manager PM
6	Anthony Musyoka	KETRACO	Senior Manager P&PD
7	Erick Ngala	PAC	Managing Partner
8	Beryl Ajwang'	EED	Senior Manager

GDC – 08/10/19

#	Name	Organization	Role/Position
1	Caroline Tele	GDC	VRE Committee Member
2	Michael Simiyu	GDC	Chief Officer Project Management
3	Beatrice Kipchumba	GDC	Planning Officer Corporate Planning & Strategy
4	Martha Ngugi	GDC	Human Resource Development
5	Faith Muthoni	GDC	Planning Officer Corporate Planning & Strategy
6	Martha Mburu	GDC	VRE Committee Member
7	Murefu Barasa	EED	Managing Partner
8	Martin Kitetu	EED	Senior Associate

REREC – 16/10/19

#	Name	Organization	Role/Position
1	Betty Akoth	GIZ	Project Advisor
2	Murefu Barasa	EED	Mg. Partner
3	Martin Kitetu	EED	Senior Associate
4	Jonathan Mbutu	REREC	Power Eng
5	Frida Manyara	REREC	HR

MoE – 16/10/19

#	Name	Organization	Role/Position
1	Betty Akoth	GIZ	Project Advisor
2	Murefu Barasa	EED	Mg. Partner
3	Martin Kitetu	EED	Snr Associate
4	Eng. Isaac Kiva	MoE	SRE
5	Chrispin O. Lupe	MoE	Chief Geologist
6	Tom Maruti	MoE	Economist
7	Mungai Kihara	MoE	Engineer
8	Nancy Wachira	MoE	
9	Julius Mwathani	MoE	

ANNEX 2: ONLINE ASSESSMENT QUESTIONNAIRE

1. Please select your Organization
   - ☐ Ministry of Energy (MOE),
   - ☐ Energy and Petroleum Regulatory Authority (EPRA),
   - ☐ Kenya Electricity Transmission Company (KETRACO),
   - ☐ Kenya Electricity Generating Company (KenGen),
   - ☐ Kenya Power,
   - ☐ Geothermal Development Company (GDC),
   - ☐ Nuclear Power and Energy Agency (NuPEA),
   - ☐ Rural Electrification and Renewable Energy Corporation (REREC)

2. How many years have you worked with this organization?

3. Please select your age bracket

   ☐ Less than 25, ☐ 26 to 35, ☐ 36 to 45, ☐ 46 to 55, ☐ Greater than 55

4. Please select your gender

   ☐ Male, ☐ Female

5. How would you classify your training background?

   ☐ Engineering, ☐ Finance/Accounts, ☐ Economist, ☐ Management, ☐ Statistician, ☐ Geologist, ☐ Other______________________________

6. What is your highest level of formal training?

   ☐ Certificate, ☐ Diploma, ☐ Bachelor's degree, ☐ Master's degree, ☐ Doctorate degree, ☐ No formal training

7. VRE management starts from project origination, project integration to project operation. In relation to your roles in the management of VRE and on a scale of 1-5, how do your rate your capacity to effectively deliver your tasks? (1 being least equipped to 5 being very well equipped) ______________________________

8. Please list the specific types of training that you would need to enhance your capacity in managing VRE

9. Please list the specific types of equipment (including computer software and hardware) that you would need to enhance your capacity in managing VRE

10. How would you rate your workload on a scale of 1 - 5, on tasks related to managing VRE? (1 being least manageable and 5 being most manageable)

11. List actions that would reduce your workload on tasks related to managing VRE? (Enter N/A if work load is manageable)

ANNEX 3: SEMI-STRUCTURED QUESTIONNAIRE

Joint Session

1. How has your role changed under the Energy Act?
2. Along the VRE value chain – origination + integration + operations, please list all the staff and departments/divisions that contribute to the management of VRE?

Names	Department	Role e.g. business development	Qualification e.g systems engineer, statistician, finance analyst

3. How is the implementation of the LCPDP and FiT process coordinated?
4. How can the LCPDP process be improved?
5. How can the FiT policy process be improved?
6. How often are the VRE (especially wind) resource maps reviewed?
7. Should there be a national cap (%) of VRE contribution?

[Follow up on the general Qs sent in advance]

HR Team

1. Complete the general information request
2. Do you have specific training for persons involved in regulating VRE projects?
3. If yes, a) how are the training needs identified, and b) how frequent is the training done (/year)?, and c) which institutions support with training?

Management Team & LCPDP

1. What capacity needs do you have to improve your contribution of the LCPDP process?
2. What capacity needs do you have to improve your contribution of the FiT process?
3. Ask all the respondents (individually) the following questions?
   - Which is these statements do you agree with the most:
     a. Contribution of VRE to the national grid has exceed manageable levels
     b. Contribution of VRE to the national grid is within manageable levels
     c. Contribution of VRE to the national grid is below manageable levels

d. I do not know

- On a scale of 1 – 5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the current contribution (15%) of VRE?
  a. 1
  b. 2
  c. 3
  d. 4
  a. 5

- On a scale of 1 – 5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the future contribution (23%) of VRE?
  a. 1
  b. 2
  c. 3
  d. 4
  e. 5

- In your opinion, which of the following institutions requires the most support to strengthen VRE readiness?
  a. Kengen
  b. VRE IPP (LTWP and REREC)
  c. KETRACO
  d. Kenya Power
  e. EPRA
  f. MoE

- Which of following represents the most critical capacity gap in managing VRE
  a. Financial
  b. Technical
  c. Policy
  d. Human Resource
  e. I do not know

Technical/ Engineering Team

1. What capacity needs do you have to improve your contribution of the LCPDP process?
2. What capacity needs do you have to improve your contribution of the FiT process?

3. Ask all the respondents (individually) the following questions?
   - Which is these statements do you agree with the most:
     a. Contribution of VRE to the national grid has exceed manageable levels
     b. Contribution of VRE to the national grid is within manageable levels
     c. Contribution of VRE to the national grid is below manageable levels
     d. I do not know

   - On a scale of 1 – 5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the current contribution (15%) of VRE?
     a. 1
     b. 2
     c. 3
     d. 4
     e. 5

   - On a scale of 1 – 5 (with 1 being least equipped to 5 being very well equipped), how is the country equipped to deal with the future contribution (23%) of VRE?
     a. 1
     b. 2
     c. 3
     d. 4
     e. 5

   - In your opinion, which of the following institutions requires the most support to strengthen VRE readiness?
     a. Kengen
     b. VRE IPP (LTWP and REREC)
     c. KETRACO
     d. Kenya Power
     e. EPRA
     f. MoE

   - Which of following represents the most critical capacity gap in managing VRE
     a. Financial
     b. Technical
     c. Policy

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